

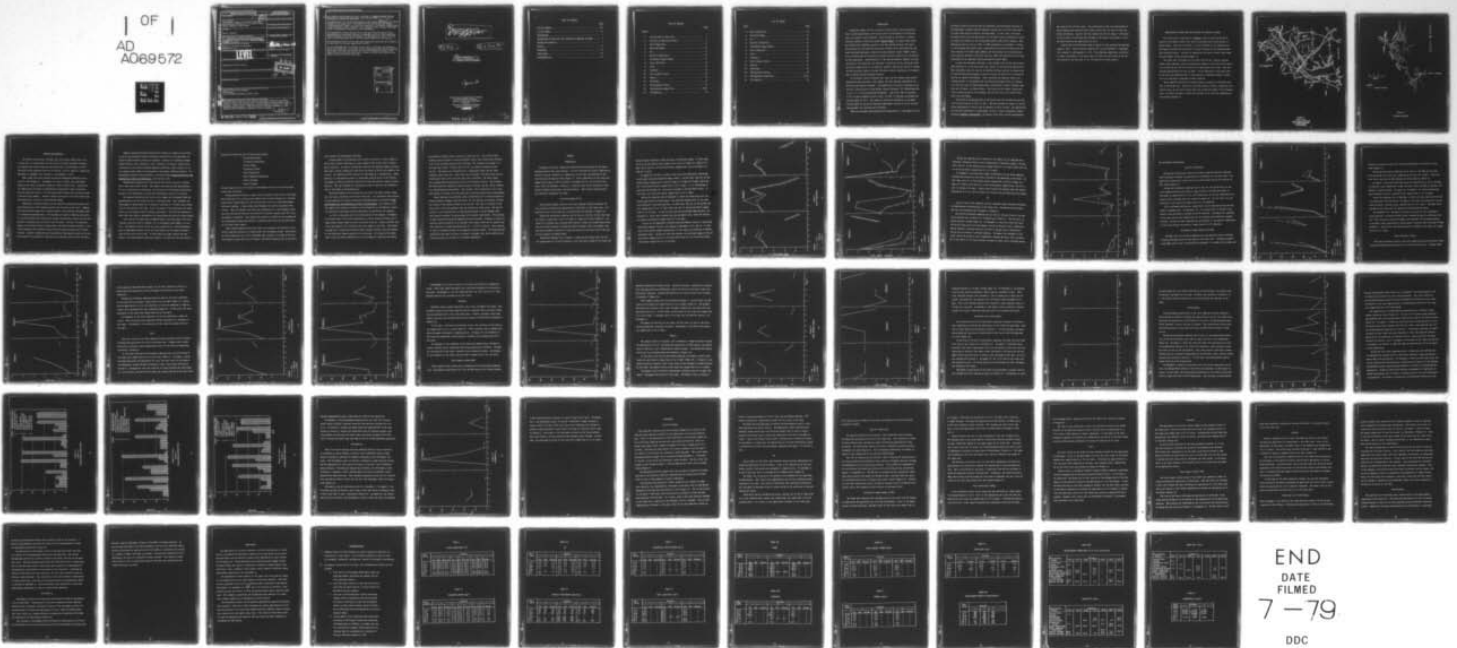
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The study area consists of 750 acres of weed-choked waters in the Rimini Trestle area near the northern end of Lake Marion, in Sumter County, South Carolina. Thirty tons of granular 2,4-D was applied on August 4-6, 1975, to eradicate Water Primrose. Then from August 27 through September 4, 1500 gallons of Ortho-Diquat was applied to control Elodea.			

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→ All sampling and analyses were done according to Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971.

The application of 2,4-D and Ortho-Diquat caused severe ^{degradation} ~~degradation~~ of the water quality in the target area. The parameters that showed the most damage included dissolved oxygen, pH, specific conductance, biochemical oxygen demand, total alkalinity, color, turbidity, total organic carbon, phenols, herbicide levels, phytoplankton populations, and chlorophyll a.

The degradation of water quality in the area was primarily caused by the decomposition of dead plant material, compounded by the low flow conditions which prevailed in the lake from August 1 to September 15. Due to this low flow, the decaying plant matter was not flushed from the study area. ←

The detrimental effects of the herbicide application persisted until October 3, 61 days after the initial application of 2,4-D.

It is recommended that if chemical control must be utilized, the following points be considered: treat early in the growing season when plants are young and tender, and before hot weather and low flow conditions prevail; treat small areas at a time and allow time to recover; monitor water quality; and adhere to herbicide label directions.

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ENVIRONMENTAL IMPACT OF THE
SOUTH CAROLINA PUBLIC SERVICE AUTHORITY'S
FY'76 AQUATIC WEED CONTROL PROGRAM IN
LAKE MARION,

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1 June 79

South Carolina Department of Health
and Environmental Control
Bureau of Field and Analytical
Services
Division of District Services
Special Services Section

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INTRODUCTION

During the summer of 1974, the South Carolina Public Service Authority (PSA) treated approximately 400 surface acres of Lake Marion with Ortho-Diquat, an extremely toxic herbicide. This was done in an effort to control extensive growths of Brazilian Elodea (Egeria densa), an exotic plant which has demonstrated tremendous growth in the lake during the past five years. This program was initiated and carried out without prior notification of the South Carolina Department of Health and Environmental Control (DHEC), therefore, no monitoring of the effects of Diquat on water quality were carried out by this department. Representatives of the Chevron Chemical Company, the manufacturer of the herbicide, did undertake a monitoring survey during and after the initial application of the material; however, Chevron has failed to release the data from this survey to either the Public Service Authority or the Department of Health and Environmental Control.

As the Public Service Authority felt that the 1974 aquatic weed control program had been successful, they sought, and were awarded, \$100,000 by the South Carolina General Assembly. This money was to be used to purchase an additional 1,500 gallons of Ortho-Diquat (Diquat dibromide [6,7-dihydrodipyrido (1,2-a : 2', 1'-C) pyrazinedium dibromide] , and thirty tons of granular 2,4-D (2,4-dichlorophenoxy acetic acid), in order to continue the program during the summer of 1975. This money was officially designated to the South Carolina Wildlife and Marine Resources Department, who was to act as the purchasing agent for obtaining the herbicides.

When the aforementioned appropriation became public, staff members of the

Division of District Services and the Compliance and Enforcement Division of the Department of Health and Environmental Control met to discuss the course of action that would be taken by the Department. At this time, a decision was made to meet with representatives of the Public Service Authority in order to discuss the details of the forthcoming aquatic weed control program. This meeting was held on July 15, 1975, at DHEC headquarters in Columbia. Present at this meeting were Howard Roach, representing the Health and Sanitation Services Section of the PSA; John Inabinet and Alton Boozer of the Special Services Section, Division of District Services, DHEC; and James Heriot and Larry McCullough of the Compliance and Enforcement Division, DHEC.

At this and subsequent meetings, it was decided that the PSA would notify DHEC officials as to the exact date and location of any herbicide application. This information would be used by the Special Services Section to design a water quality monitoring program in order to assess the effects of 2,4-D and Diquat on the aquatic environment. After surveying the numerous areas to be treated by PSA, it was decided that the monitoring program would be confined to a 750 acre tract of weed-choked waters located west of Pack's Landing, near the town of Rimini, in Sumter County. This area was the largest single area to be treated during the 1975 program, and the only area to be treated with both 2,4-D and Diquat.

Collection of background data of the Rimini area was initiated by the Special Services Section on July 24, 1975. This was followed on August 4-6 by the aerial application of thirty tons of granular 2,4-D by the PSA. The application of 2,4-D was undertaken to "knock-down", or kill, a thick overgrowth of Water Primrose (Ludwigia uruguayensis), an aquatic plant which covered approximately

500 acres of the 750 acre tract. The eradication of the overlying growth of Water Primrose was necessary before boats could enter the area to treat the Elodea with Diquat. Special Services sampled the area on August 7 and August 20 in an effort to determine what changes in the aquatic environment, if any, had been caused by the application of 2,4-D.

Application of Ortho-Diquat began on August 27 and continued through September 4, 1975. Special Services sampled the area on September 2, September 9-11, October 3, and November 5, 1975. This sampling program was carried out in order to determine if the application of Diquat had any effect on the water quality of the area and, if so, the duration of these effects.

DESCRIPTION OF STUDY AREA AND LOCATION OF SAMPLING STATIONS

The study area is comprised of a 750 acre tract of weed-choked waters located in the Rimini Trestle area near the northern end of Lake Marion, in Sumter County. The area is located 7.5 miles southeast of the confluence of the Congaree and Wateree Rivers and 0.5 miles northwest of the Seaboard Coast Line railroad trestle. The area is immediately northwest of Pack's Boat Landing near Rimini, South Carolina (Figure 1).

The study area is bordered on the south and west by a typical cypress-tupelo swamp community, known as Sparkleberry Swamp; to the north by the shoreline of Lake Marion; and to the east by the open-water of the lake. The area averages approximately 10 feet in depth. At the beginning of the study, most of the area was impassable due to thick growths of submerged Elodea, in addition to a continuous overgrowth of Water Primrose.

Three sampling stations were located along a northeast by southwest transect in the study area. Because of the heavy growth of aquatic vegetation, the stations were, by necessity, placed near the southeastern edge of the overgrown area. An effort was made to locate the stations as far into the vegetation as was possible (Figure 2).

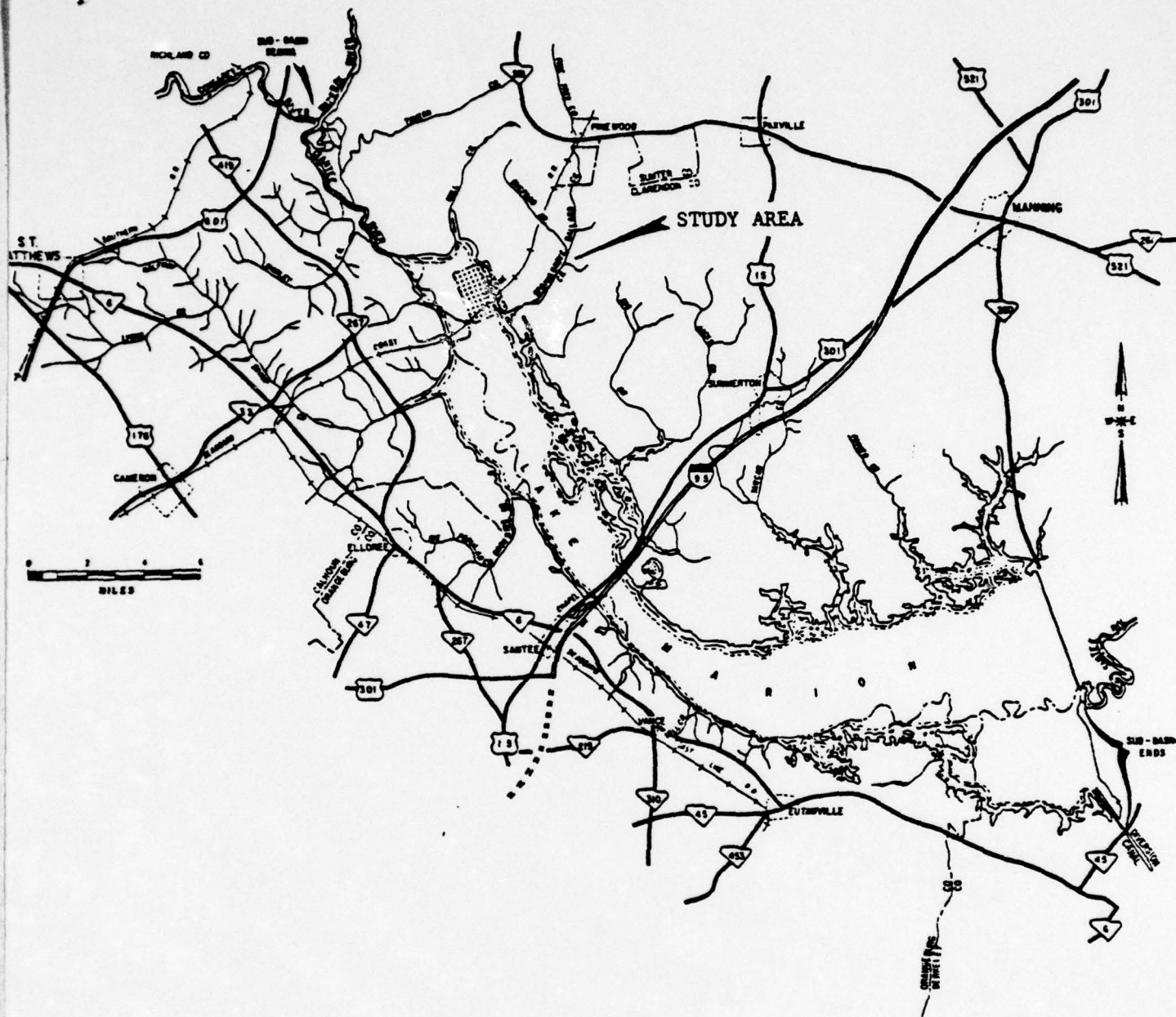


FIGURE 1
 STUDY AREA
 LAKE MARION SUB-BASIN
 SANTEE-COOPER RIVER BASIN
 SOUTH CAROLINA
 ADP CODE 62-66-04

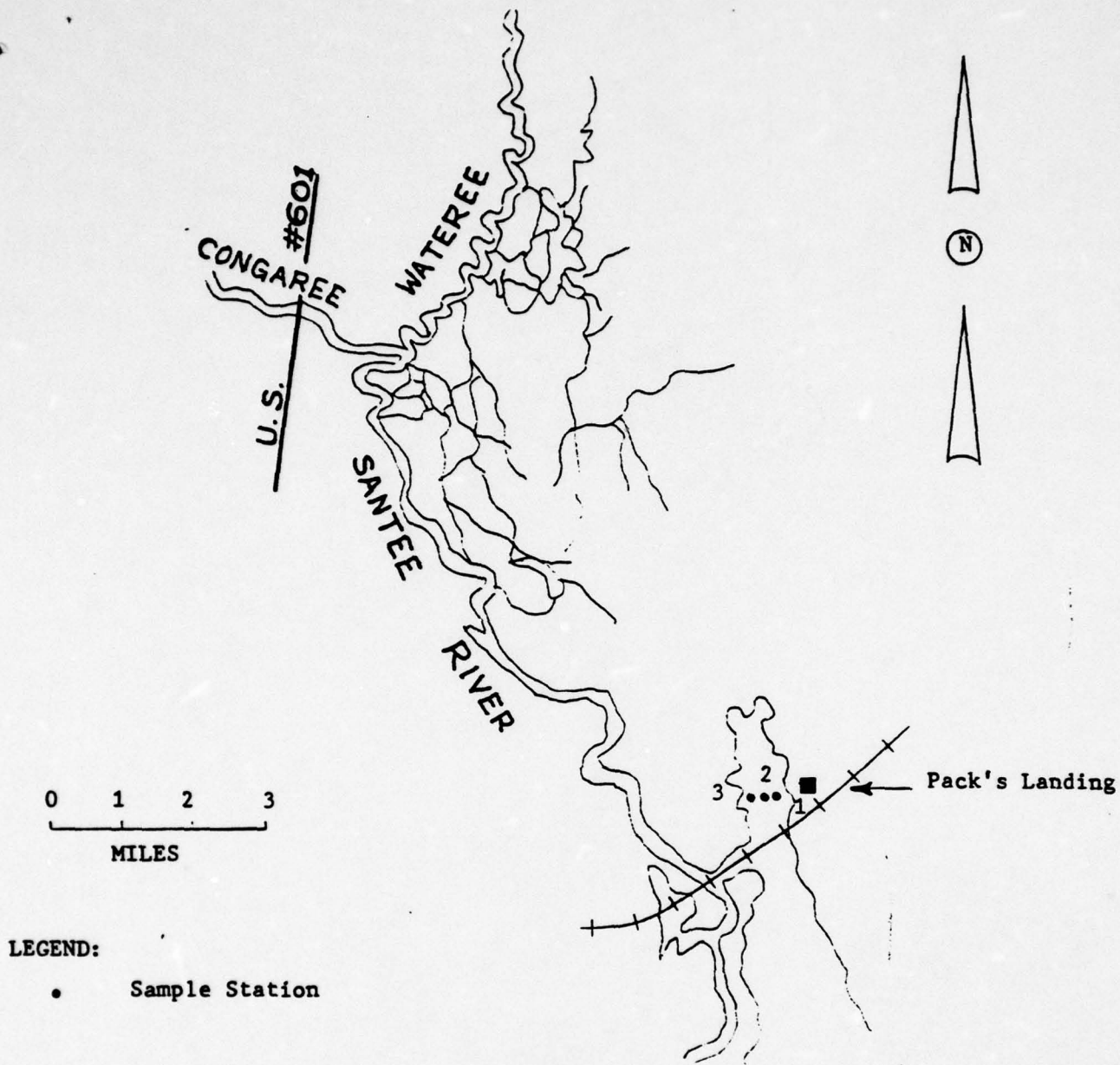


Figure 2
STATION LOCATION

METHODS AND MATERIALS

The Rimini Trestle-Pack's Landing area, the largest single area to be treated with 2,4-D and Diquat for the control of Elodea and Water Primrose, was sampled nine times during the period from July 24 to November 5, 1975. The dates of the sampling trips are as follows: July 24, August 7, August 20, September 2, September 9-11, October 3, and November 5, 1975.

Three study sites were selected during the background sampling trip on July 24, 1975 (Figure 2). Throughout the study, surface, mid, and bottom depths of the water column were sampled at each of these sites. Surface water samples were collected by submerging the appropriate sample containers one foot below the surface. Mid and bottom water samples were collected using a Van Dorn water sampler. Sediment samples from each of the three study sites were taken with a stainless steel Peterson dredge.

Temperature, dissolved oxygen, pH, and specific conductance profiles were taken during each of the sampling periods from the three study sites. Temperature and dissolved oxygen were recorded using a Yellow Springs Instruments Model 54 Temperature-Oxygen Meter. The readings were made by immersing the probe to the desired depth and recording the oxygen concentration in mg/l and the temperature in degrees celsius directly from the meter. The pH of an unaltered sample was determined using a Corning Model 610A Expand Portable pH Meter. Specific conductance was recorded using a Yellow Springs Instruments S-C-T Model 33 Meter. Specific conductance was determined by immersing the probe to the desired depth and recording the conductivity in $\mu\text{mhos/cm}$ directly from the meter.

Samples requiring detailed analyses were placed on crushed ice and transported to the Analytical Services Division laboratories of the Department of Health and Environmental Control in Columbia. Analysis of biochemical oxygen demand (5-Day), total alkalinity, color, turbidity, and phenols samples were carried out by the Central Midlands Regional Laboratory, while analysis of total organic carbon samples was performed by the Organic Chemistry Section. All sampling and analyses were performed in accordance with Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971.

Phytoplankton samples were collected one foot below the water's surface with a one liter plastic bottle. The sample was preserved with approximately 37 ml of a merthiolate preservative, and returned to the Biological Monitoring Section of the Department of Health and Environmental Control for analysis.

For species identification, the one liter sample was thoroughly mixed and approximately 40 ml was drawn off into a centrifuge tube. This subsample was centrifuged at medium speed for 15 minutes, resulting in a visible algal concentrate in the bottom of the tube. One or two drops of the concentrate was transferred to a microscope slide to prepare a wet mount. The slide was examined at 100X, 400X, and 1000X as appropriate for identifying each specie of algae present.

Total counts were made using a Sedgwick-Rafter counting chamber (S-R cell). A pasteur pipet was used to transfer 1 ml of thoroughly mixed sample to a S-R cell. Two lengths (strips) of the cell were counted with a calibrated Whipple grid at 200X magnification, unless the algal density of the sample exceeded a tally of 100 on the first strip. In cases where the algal density was much greater, ten random Whipple grids were counted. An eight key tally was used to

separate the count into the following algal groups:

Cocoid Blue-greens

Filamentous Blue-greens

Cocoid Greens

Filamentous Greens

Green Flagellates

Other Pigmented Flagellates

Centric Diatoms

Pennate Diatoms

Percent composition for each group was determined from the tally and the total counts were calculated.

Phytoplankton chlorophyll a samples were collected in the field in the shade. Three replicate 15 ml surface water samples were filtered through a 0.3 um glass fiber filter (Gelman type A-E) wetted with about 0.3 ml of a saturated aqueous solution of Mg CO₃. A hand vacuum pump (Nalgene) was used at no greater than 9.8 psi. After filtration, the filter was transferred to a foil-wrapped, screw-cap test tube and the tube was filled with 90 % aqueous acetone until the filter was completely immersed. The samples were stored on crushed ice and transported to the Biological Monitoring Section's laboratory where they were stored frozen for no longer than a month.

When a phytoplankton extract was ready to be analyzed, the contents of the extract tube were placed in a tissue grinder and thoroughly ground. Each extract was then transferred to a 15 ml centrifuge tube, brought to a volume of 10.5 ml, centrifuged at about 500 g for 15 minutes, and finally decanted into an optically

clean cuvette for fluorometric analysis.

A Turner Model III fluorometer with filters to excite at a wave length of 430 nm and to detect emissions at a wave length of 663 nm was used in chlorophyll a analysis. An initial reading was taken on the extracted sample outlined above and a second reading was taken after two drops of 1N HCL were added to the cuvette. The addition of HCL converts all chlorophyll a to pheophyton a. (Pheophyton a is a degradation product of chlorophyll a which occurs in all natural chlorophyll a extracts and which fluoresces in the same spectral region as chlorophyll a). The two fluorometric readings were used to calculate the concentration of chlorophyll a and pheophyton a.

Herbicide samples were collected one foot below the waters surface using one liter glass containers with teflon-lined caps. All containers had previously been prepared for organics sampling following methods as outlined in Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971. The samples were placed on crushed ice and transported to the Chemical Laboratory Division of the South Carolina Department of Agriculture for analysis.

In order to determine the 2,4-D concentration of the sample, a subsample of filtered water (25 ml) was transferred to a 50 ml volumetric flask, and enough sodium sulfate added to form a saturated solution. Aqueous sulfuric acid (1 ml) and exactly 5 ml of diethyl ether were added to the flask. The mixture was made up to volume with saturated sodium sulfate solution, and the contents of the flask were shaken vigorously for one minute. An aliquot of the ether layer (3 ml) was then transferred to a 10 ml volumetric flask and the solvent

evaporated to dryness under a current of clean dry air. The residue after clean-up, was dissolved in absolute methanol (10 ml) and concentrated sulfuric acid (1 ml) was added dropwise with swirling. The solution was brought to a boil and then cooled. Diethyl ether (10 ml) was added, followed by water (30 ml). The mixture was transferred to a separatory funnel and the lower (aqueous) layer drawn off. Both layers were retained. The water layer was extracted with ether (5 ml) and the lower layer discarded. The ether layers were combined and extracted twice with 10 ml portions of water. The solution was then dried over anhydrous sodium sulfate, filtered, and the solvent removed in a Kuderna-Danish concentrator. The residue, after dissolving it in a standard volume of solvent, was then analyzed by electron capture gas chromatography.

Diquat analysis was performed using a modification of a method designed by Chevron Chemical Company, Ortho Division, for the analysis of Paraquat residues. An outline of the original method is as follows: The crop is refluxed in sulfuric acid to free the paraquat from the absorbed or bound state. The extract (either as is or neutralized) is then passed through a cation exchange resin which absorbs paraquat, but passes most of the plant constituents. The paraquat is then eluted with saturated ammonium chloride solution. Paraquat is easily reduced by sodium dithionite to an unstable free radical which has an intense blue color and also a strong absorption peak ($E = 4 \times 10^{-4}$) at 394 m μ . This reaction is used to estimate paraquat in the ammonium chloride eluate. The background absorption in the region of 394 m μ is almost a straight line, which enables an accurate correction to be made for irrelevant absorption.

RESULTS

Temperature

Throughout the study, temperature profiles and fluctuations of the three sampling stations were quite similar. A cyclic fluctuation in water temperature, related to natural seasonal air temperature in the area, was observed at the three stations during the study (Figure 3). Water temperature of the study area ranged from a high of 32°C at Station 2 on August 20 to a low of 17°C at Stations 1 and 2 on November 5 (Table 1). There was very little variation in temperature between surface, mid, and bottom waters. This profile characteristic was consistent throughout the study.

Dissolved Oxygen (D.O.)

The dissolved oxygen levels of the three sampling stations underwent severe decreases following the application of herbicides to the study area. Pre-application D.O. levels were not re-established until November 5 (Figure 4).

During the preliminary sampling trip of July 24, the D.O. of the study area was found to range from a low of 3.0 mg/l to a high of 6.0 mg/l (Table 2). The lowest D.O. readings were recorded from Station 2, which was located down-stream from the thickest growths of Elodea and Water Primrose; while the highest readings were recorded at Station 3, which was located on the south side of the study area, nearest the Santee River.

During the sampling trip of August 7, which was three days after the initial application of 30 tons of granular 2,4-D, the water column of all three sam-

pling stations exhibited a sharp decrease in dissolved oxygen. At this time, the D.O. of the surface water ranged from a low of 1.8 mg/l to a high of 3.0 mg/l; while the D.O. of the bottom waters ranged from a low of 0.8 mg/l to a high of 2.4 mg/l.

On August 20, the water column of the study area exhibited a continuing trend toward decreased dissolved oxygen levels. On this date, the D.O. of the surface waters ranged from a low of 0.9 mg/l to a high of 2.0 mg/l; while the D.O. of the bottom waters ranged from 0.5 to 1.2 mg/l. It is interesting to note that the minimum D.O. levels were recorded at the mid depth levels. At this point, the dissolved oxygen ranged from 0.2 to 1.2 mg/l.

During the sampling trip of September 2, which was seven days after the initial application of Ortho-Diquat, the dissolved oxygen level of the study area exhibited a continued decrease. On this date, the D.O. of the surface waters ranged from 1.0 to 2.7 mg/l; while the D.O. of the bottom waters ranged from 0.3 to 0.6 mg/l. As was the case with the preceding sampling date, the minimum D.O. levels were recorded from the mid depth level, where the dissolved oxygen concentration ranged from 0.2 to 0.8 mg/l.

As part of the Department of Health and Environmental Control's continuing Lake Study Program, Station 2 was sampled on September 9, 10, and 11. At this time, the dissolved oxygen concentration of the study area continued to exhibit decreased levels. During this three day period, the dissolved oxygen of the surface waters ranged from 0.4 to 0.9 mg/l; while the D.O. of the mid and bottom level waters ranged from 0.1 to 0.8 mg/l.

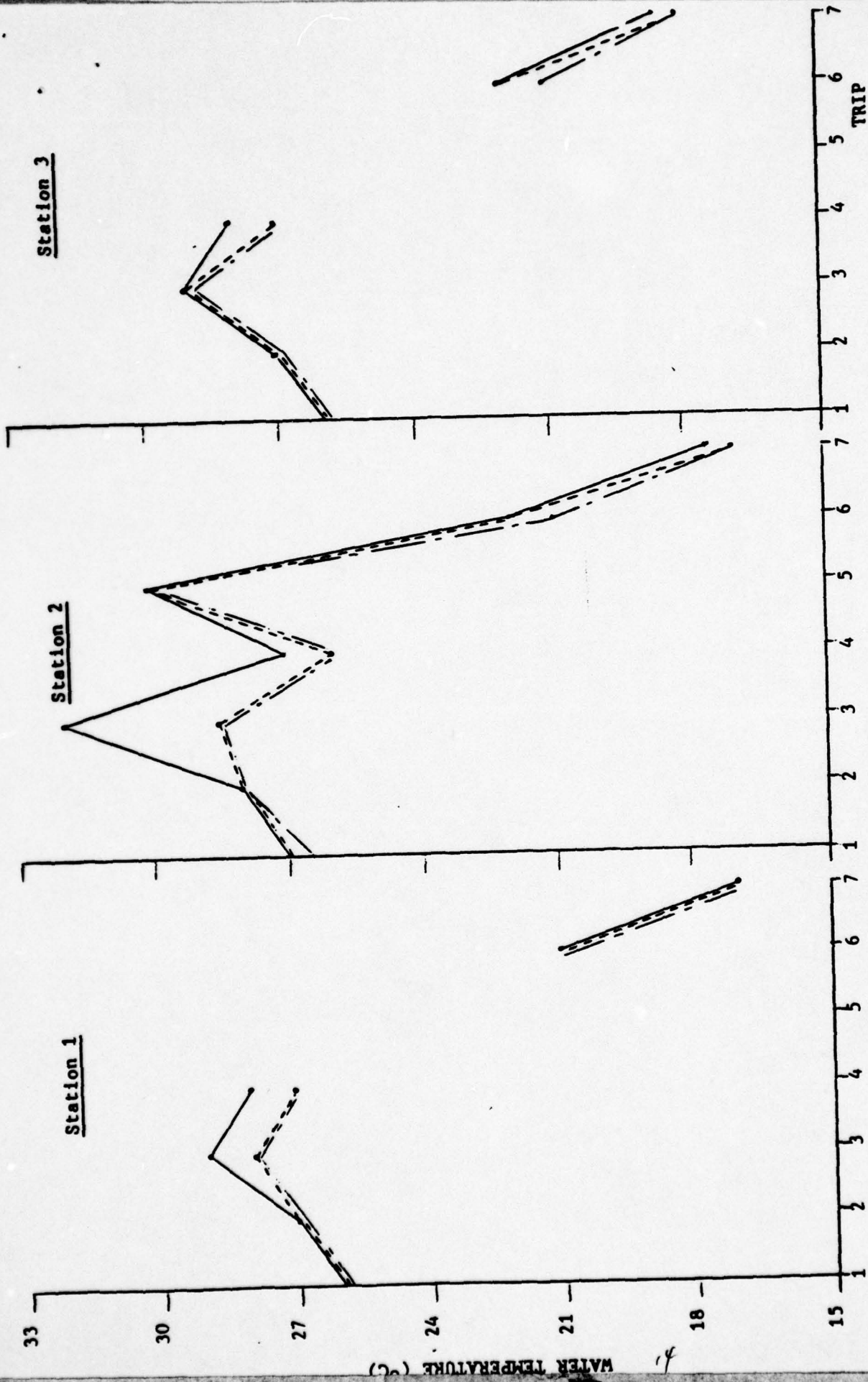


Figure 3
WATER TEMPERATURE

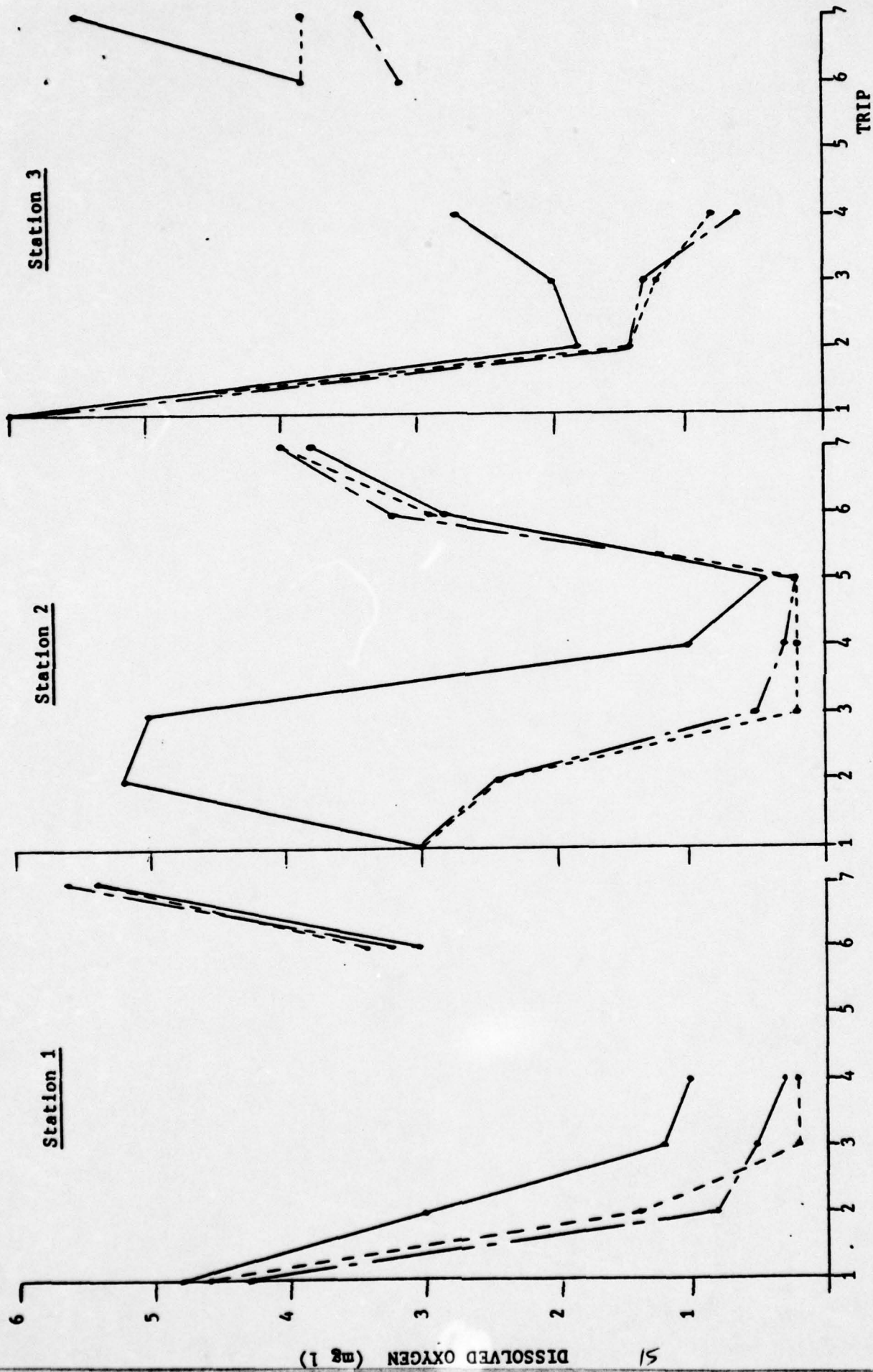


Figure 4
DISSOLVED OXYGEN

Legend:
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During the sampling trip of October 3, the waters of the sampling area exhibited a marked increase in the concentration of dissolved oxygen. On this date, the D.O. of the surface waters ranged from 2.8 to 3.8 mg/l; while the D.O. of the bottom waters ranged from 3.1 to 3.3 mg/l.

By November 5, the dissolved oxygen concentration of the three sampling stations had returned to the levels recorded at the beginning of the study. At this time, the D.O. of the surface waters ranged from a low of 3.8 mg/l to a high of 5.5 mg/l; while the D.O. of the bottom waters ranged from a low of 3.4 mg/l to a high of 5.6 mg/l. Exactly three months had elapsed since the initial application of 2,4-D, and two months had elapsed since the application of Diquat.

pH

The pH of two of the sampling stations underwent sharp increases following the application of Ortho-Diquat to the study area. Pre-application pH levels were not re-established until November 5 (Figure 5).

During the preliminary sampling trip on July 24, the pH of each of the sampling stations was recorded at 6.5 standard units (Table 3). This pH level remained constant through August 20. On September 2, which was seven days after the initial application of Ortho-Diquat, the pH of Stations 2 and 3 exhibited a marked increase, reaching levels of 8.0 and 8.4 standard units respectively. The pH level of Station 1 remained constant. Throughout the remainder of the study, the pH of Stations 2 and 3 exhibited a gradual decrease, until on November 5 the levels of all three stations returned to those levels recording during

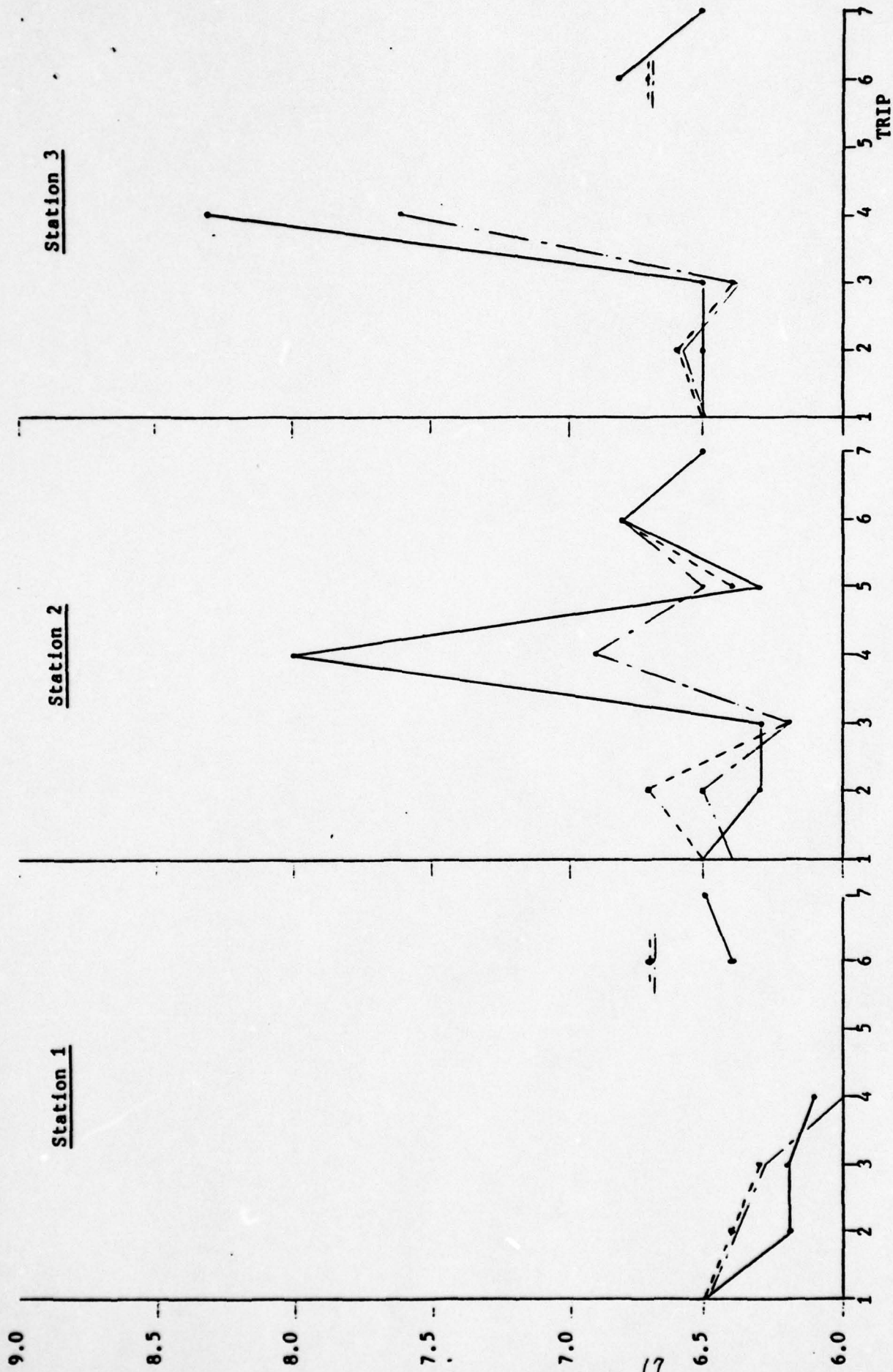


Figure 5
pH

Legend:
 Top ———
 Midpoint - - - -
 Bottom - · - · -

the preliminary examination.

Specific Conductance

The specific conductance levels of the three sampling stations underwent sharp increases following the application of herbicides to the study area. Pre-application conductivity levels were not re-established during the duration of this study (Figure 6).

During the preliminary sampling trip of July 24, the conductivity of the three sampling stations was found to range from 80 to 85 umhos/cm (Table 4). Following the application of 2,4-D, the conductivity of the area exhibited an increase, until a maximum level was reached on August 20. On this date, the conductivity of the study area ranged from 92 to 142 umhos/cm.

Due to equipment malfunction, conductivity was not measured during the September 2 sampling trip. On September 9-11, the conductivity of Station 2 was found to have decreased to between 90 and 95 umhos/cm. Throughout the remainder of the study period, the conductivity of the sampling area exhibited a gradual increase. During the final sampling date of November 5, the specific conductance of the three stations was found to range from 104 to 125 umhos/cm.

Biochemical Oxygen Demand (Five-Day)

The BOD₅ levels of the three sampling stations exhibited severe increases following the application of herbicides to the study area. Although pre-application BOD₅ levels were re-established by September 9, the BOD₅ of the study area

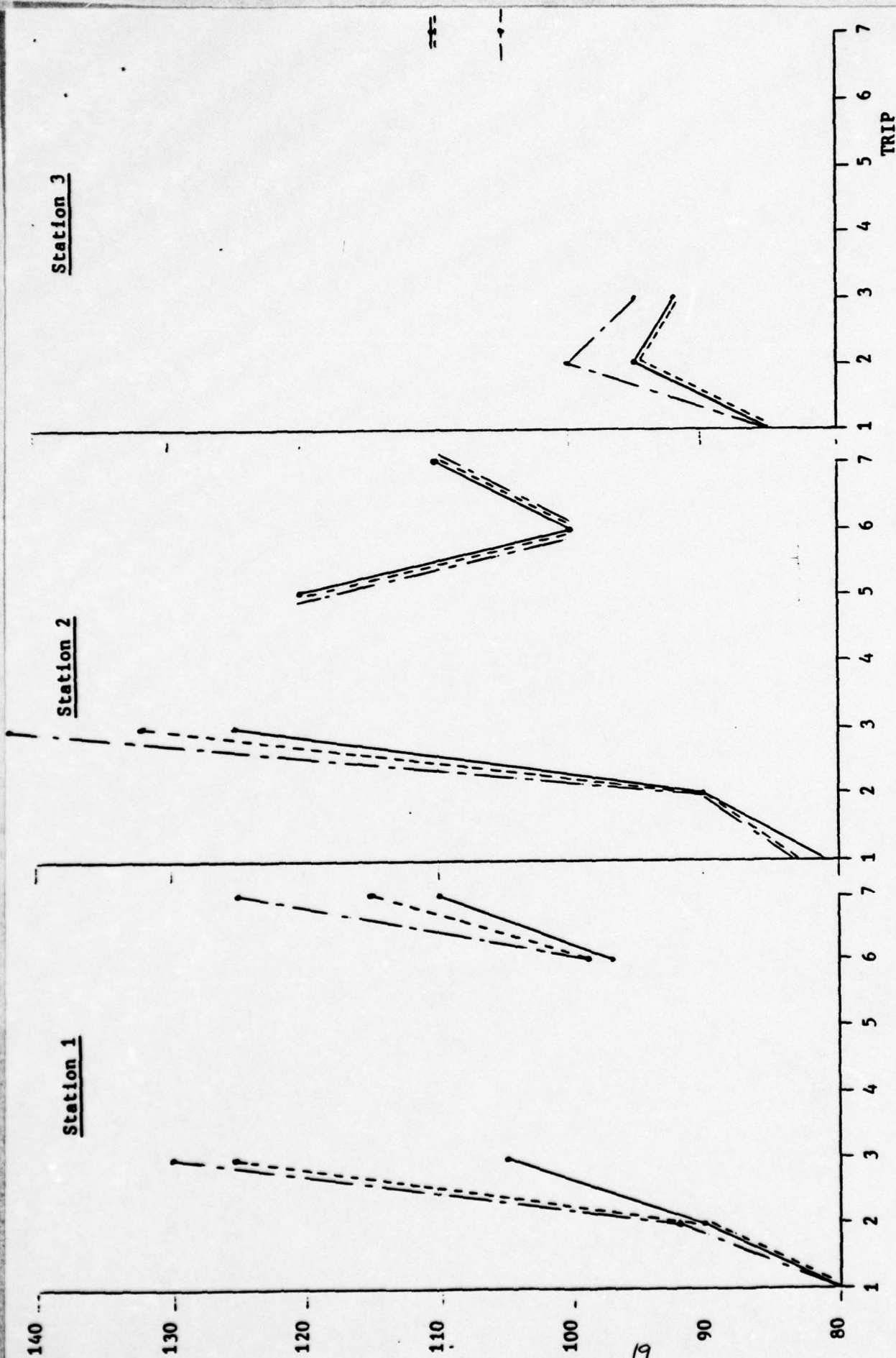


Figure 6
SPECIFIC CONDUCTANCE

Legend:
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 - · - Bottom

underwent a second increase which continued throughout the duration of this study (Figure 7).

During the preliminary sampling trip on July 24, the BOD₅ of the study area was found to be quite low, ranging from 0.5 mg/l to 1.0 mg/l. There was very little variation in BOD₅ between the three stations (Table 5).

On August 7, which was three days after the application of 2,4-D, the BOD₅ at Stations 1 and 2 exhibited a slight increase, while the BOD₅ of Station 3 exhibited a slight decrease. By August 20, the BOD₅ of all three stations had shown a marked increase, reaching levels ranging from 1.4 to 2.5 mg/l.

During the sampling trip of September 2, which was seven days after the initial application of Ortho-Diquat, the BOD₅ of the study area exhibited a considerable increase, reaching levels ranging from 4.0 to 5.6 mg/l. The BOD₅ levels recorded on this date were the maximum recorded during the study.

On September 9-11, the BOD₅ of Station 2 was found to have undergone a marked decrease, returning to those levels recorded during the preliminary survey. This trend was reversed throughout the remainder of the study; however, as the BOD₅ levels demonstrated a second general increase which continued through November 5. During this last sampling effort, the BOD₅ of the study area ranged from 1.0 to 1.7 mg/l.

Total Alkalinity (CaCO₃)

The total alkalinity levels of the three sampling stations exhibited a small increase following the application of 2,4-D to the study area. Although these

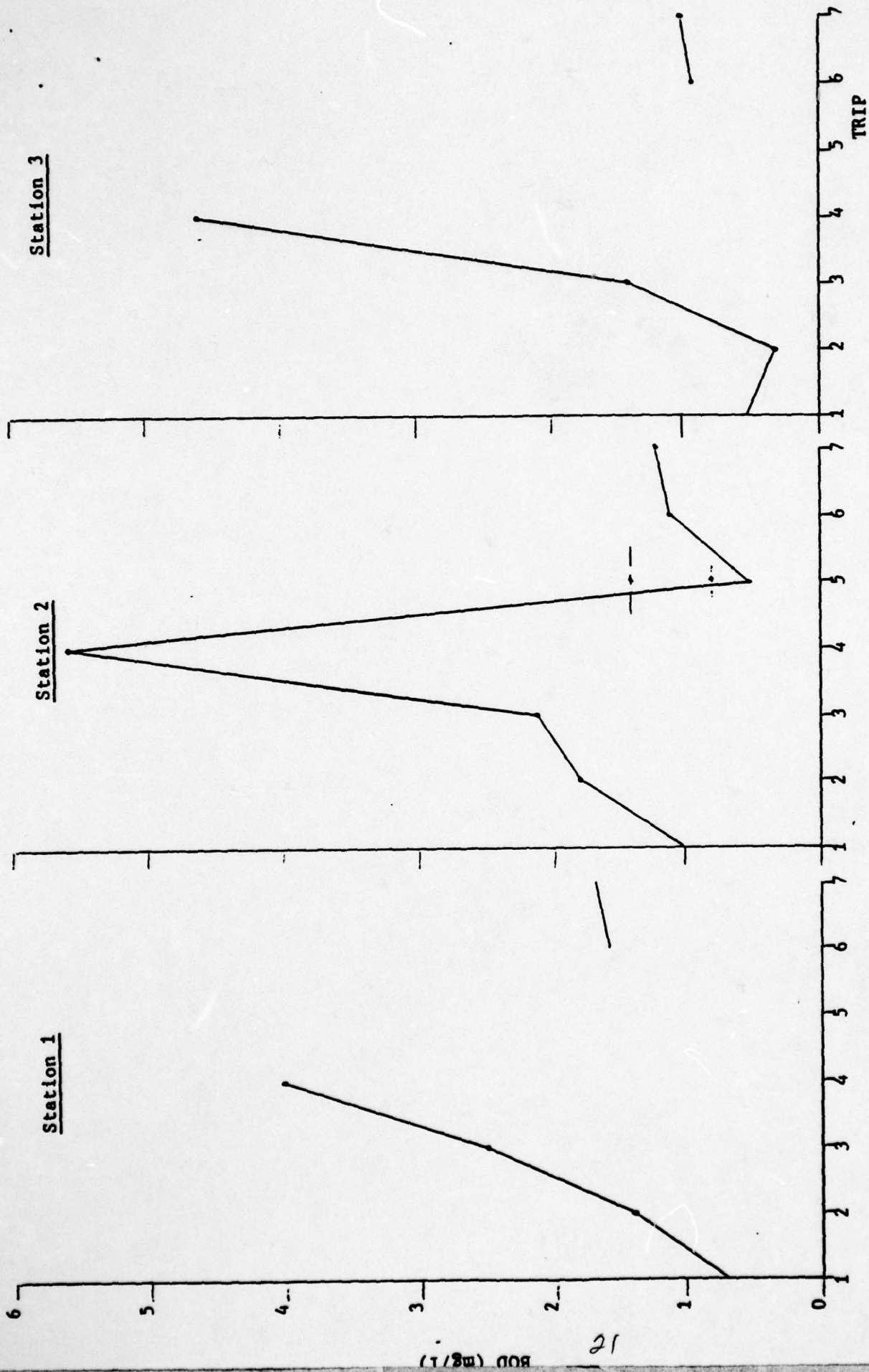


Figure 7
BIOCHEMICAL OXYGEN DEMAND

Legend:
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 - - - - Midpoint
 - · - · Bottom

levels generally decreased after August 20, the total alkalinity levels remained above pre-application levels throughout the duration of the study (Figure 8).

During the preliminary sampling survey of July 24, the total alkalinity of the study area was found to range from 8.0 to 12.0 mg/l (Table 6). Following the application of 2,4-D, the alkalinity of the area exhibited a slight increase, until maximum levels were reached on August 20. On this date, the total alkalinity of the study area ranged from 18.0 to 30.0 mg/l.

By September 2, the total alkalinity of the area exhibited a slight decrease. These decreased levels remained constant throughout the remainder of the study. On November 5, the alkalinity of the study area ranged from 10.0 to 16.0 mg/l.

Color

The color levels of the three sampling stations underwent severe increases following the application of 2,4-D to the study area. Original color levels were quickly restored, with pre-application color levels being re-established by October 3 (Figure 9).

At the time of the July 24 preliminary sampling trip, the color levels of the study area ranged from 45 to 70 color units (Table 7). On August 3, which was three days after the application of 2,4-D, the color level of the study area exhibited a slight increase at Stations 1 and 2, and a small decrease at Station 3. By August 20, the color level of all three stations had risen sharply. On this date, the color of the study area ranged from 120 to 240 color units.

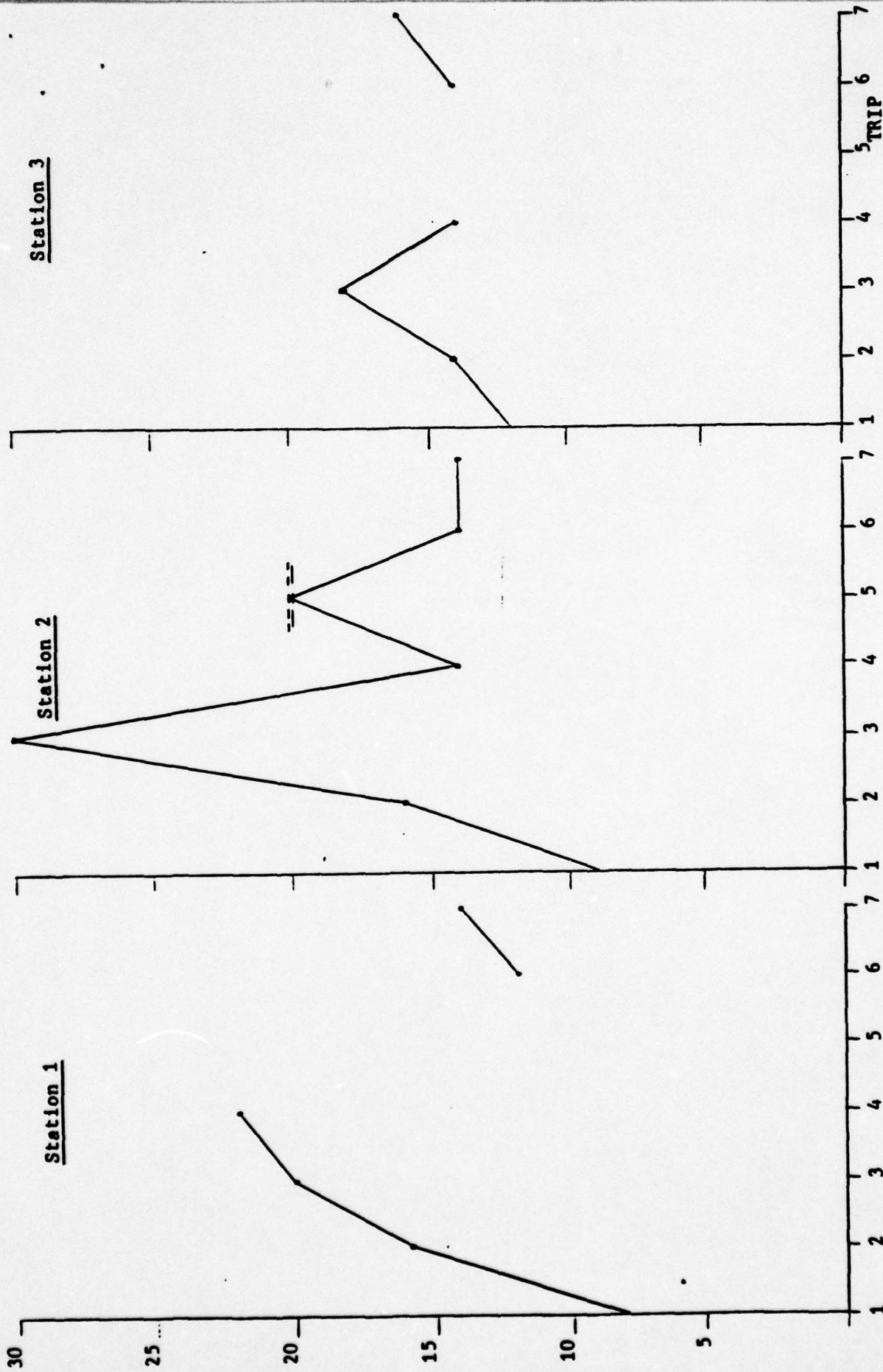


Figure 8
TOTAL ALKALINITY

Legend:
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 - - - Bottom

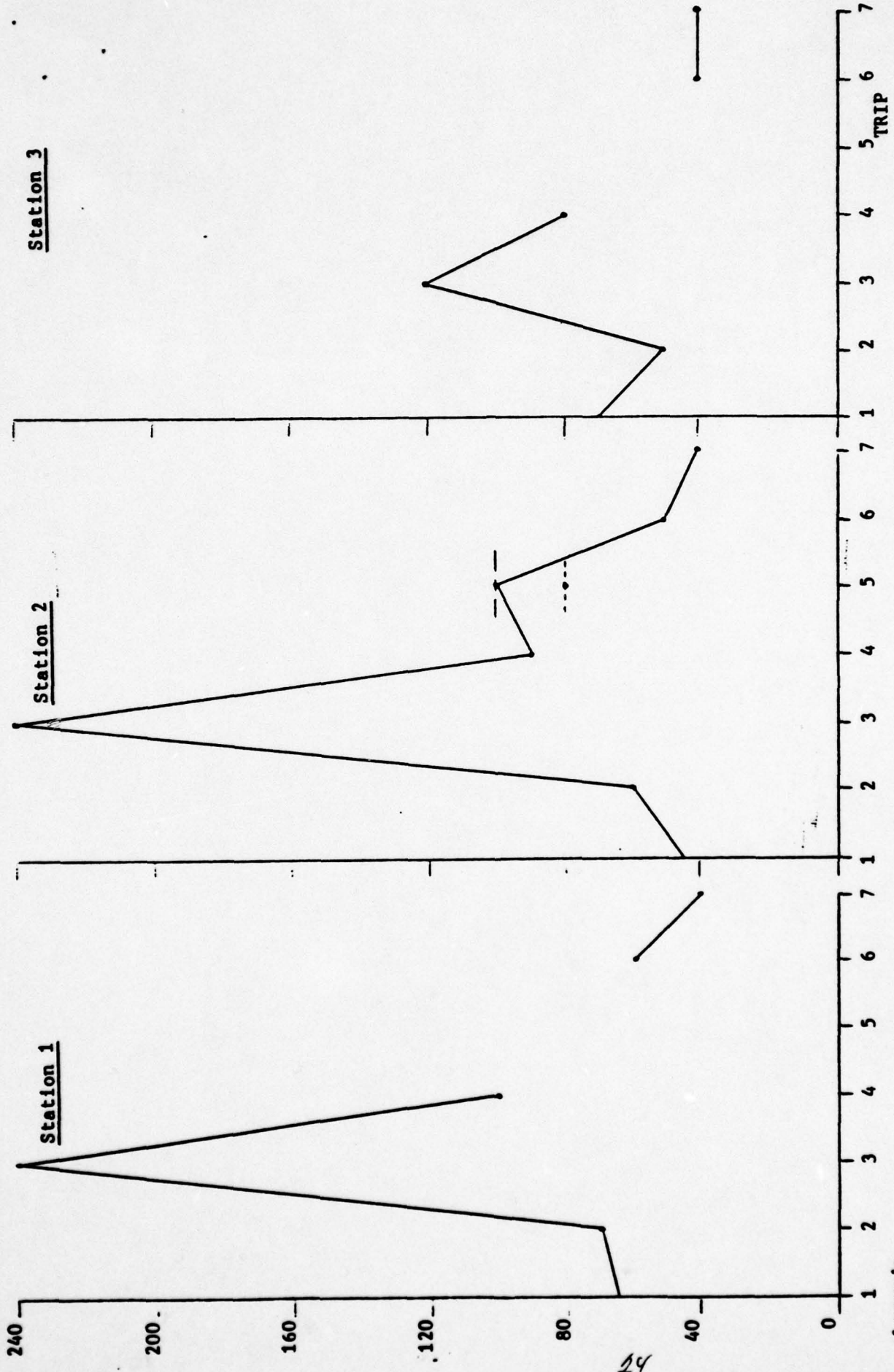


Figure 9

COLOR

- Legend:
- Top
 - - - Midpoint
 - · - Bottom

On September 2, the color levels of the study area exhibited a marked decrease. This trend toward decreased color continued throughout the duration of the study. By November 5, the last sampling date, the color level of all three sampling stations was recorded as 40 color units.

Turbidity

Turbidity levels closely paralleled color levels throughout the study. The turbidity levels of the three sampling stations underwent sharp increases following the application of 2,4-D to the study area. Original turbidity levels were quickly restored, with pre-application levels being re-established by September 2 (Figure 10).

At the time of the July 24 preliminary survey, the turbidity of the study area ranged from 3.5 to 4.5 units (Table 8). These turbidity levels remained constant throughout the August 3 sampling period. On August 20, the turbidity of the study area exhibited a sharp increase, reaching levels ranging from 30 to 150 units.

On September 2, the turbidity of the study area demonstrated a marked decrease, reaching levels consistent with the pre-application turbidity. Throughout the duration of the study, turbidity levels remained constant. By November 5, the turbidity of the study area was found to range from 8.5 to 11.0 units.

Total Organic Carbon (TOC)

Total organic carbon levels were not measured on the preliminary sampling trip. Following the application of 2,4-D, the TOC levels of all three stations

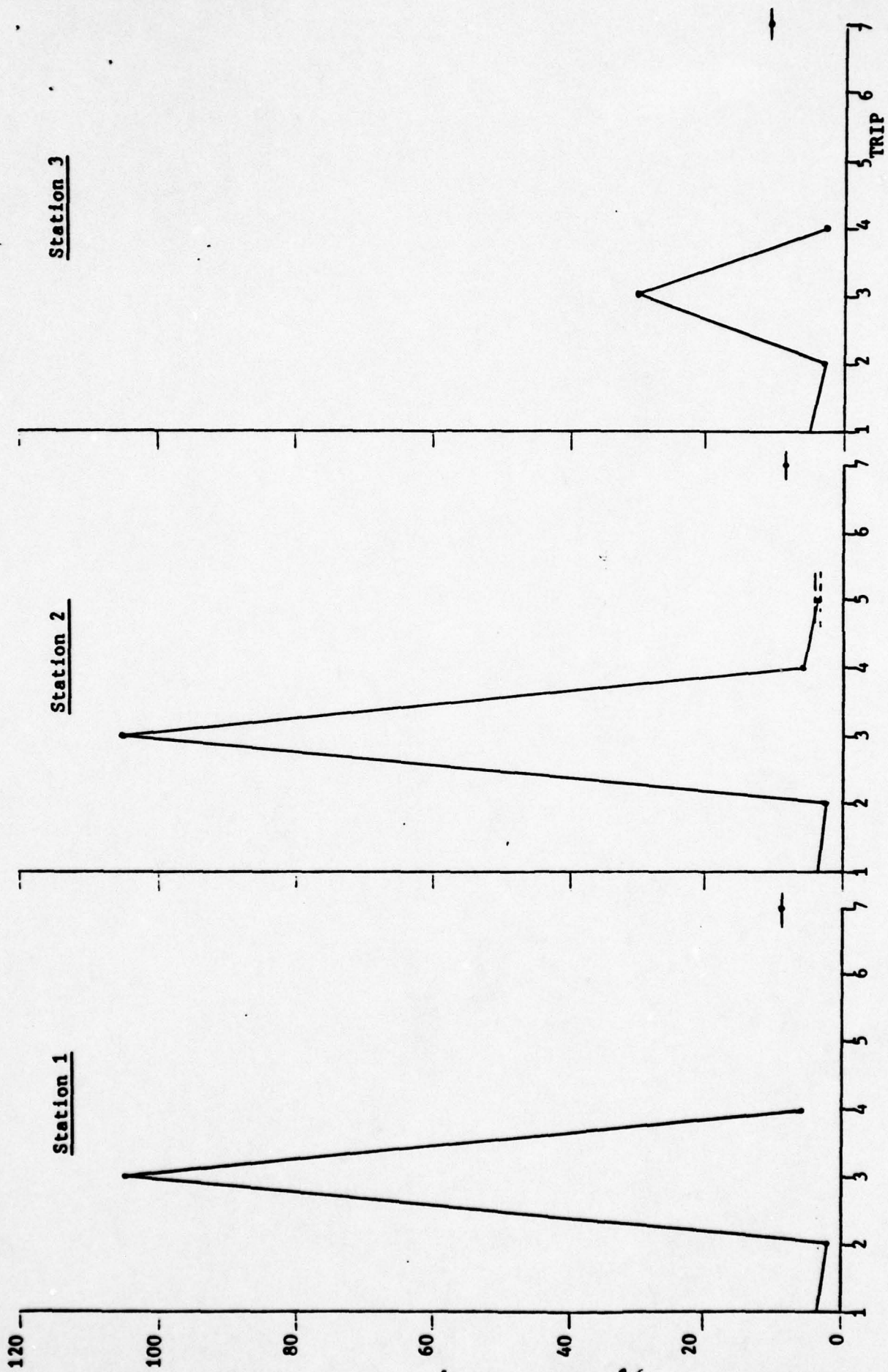


Figure 10
TURBIDITY

Legend:
 — Top
 - - - Midpoint
 - · - Bottom

exhibited abnormally elevated values. The TOC of Station 1 exhibited an increase after the application of Ortho-Diquat, while the levels at Stations 2 and 3 demonstrated a decrease. Minimum TOC values for all three stations were recorded on November 5 (Figure 11).

Total organic carbon was first measured on August 7. On this date, the TOC levels of the study area ranged from 11.4 to 13.9 mg/l (Table 9). The maximum TOC levels for Stations 2 and 3 were recorded on August 20, two weeks after the application of 2,4-D. At this time, the TOC levels of the study area ranged from 14.0 to 19.0 mg/l. A maximum level of 17.0 mg/l was recorded for Station 1 on September 2.

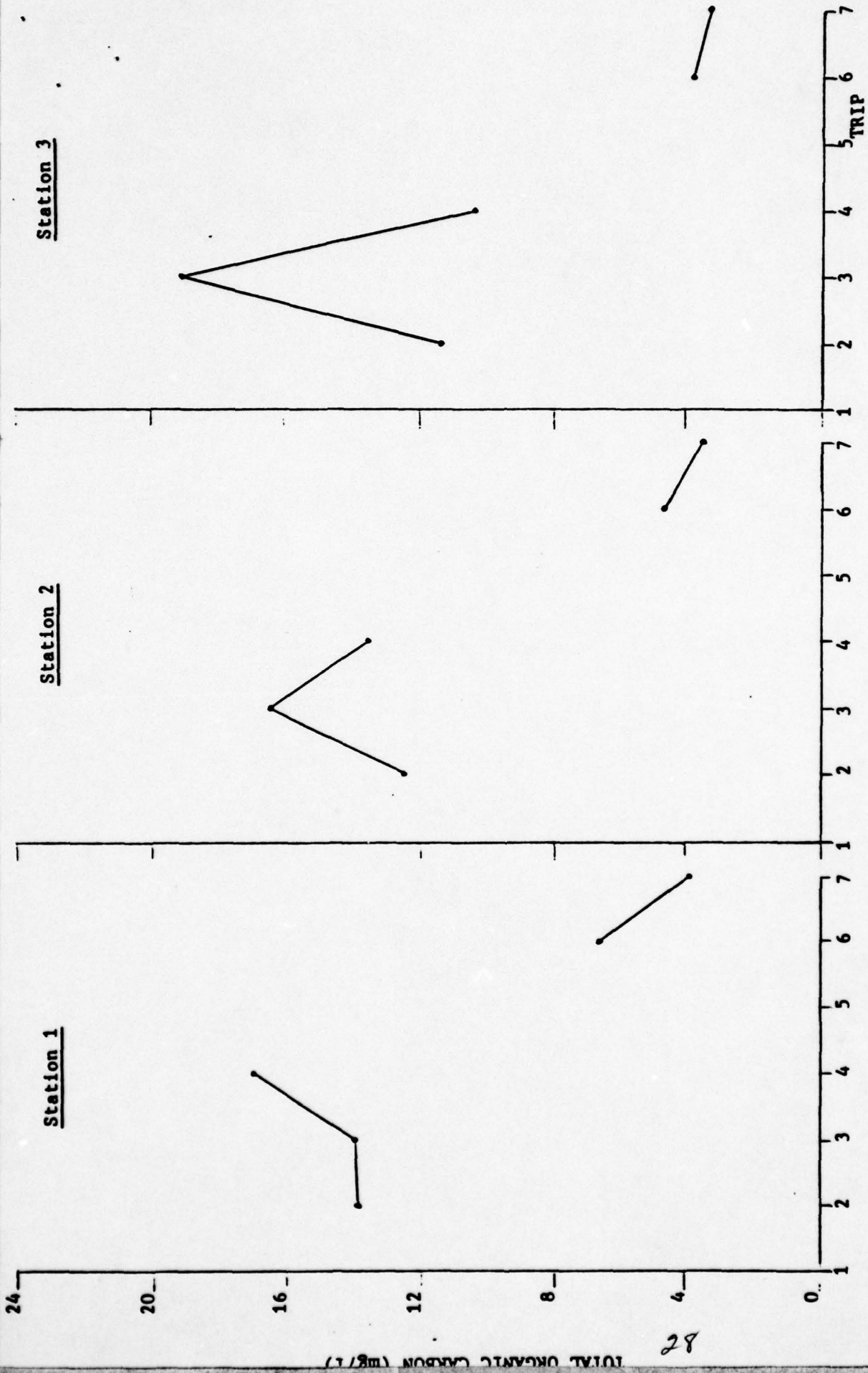
Throughout the duration of the study, the TOC levels of each of the three stations exhibited a continual decrease. By November 5, the TOC of the study area ranged from 3.3 to 3.9 mg/l.

Phenols

The phenols levels at Stations 1 and 3 exhibited a slight decrease following the application of 2,4-D. Following the application of Ortho-Diquat, the phenols level at Stations 2 and 3 demonstrated a sharp increase. Pre-application phenols levels were not re-established until November 5 (Figure 12).

At the time of the July 24 preliminary sampling, the phenols levels of the study area were found to range from 4.0 to 5.0 mg/l (Table 10). On August 7, the phenols levels of Stations 1 and 3 were found to have undergone a slight decrease. On this date, the phenols levels of the study area ranged from 2.0 to 4.0 mg/l.

The phenols level of Station 1 maintained a constant value of 4.0 mg/l from August 7 throughout the duration of the study. The phenols level of Station 2



Legend: Top (solid line), Midpoint (dashed line), Bottom (dash-dot line)

Figure 11
TOTAL ORGANIC CARBON

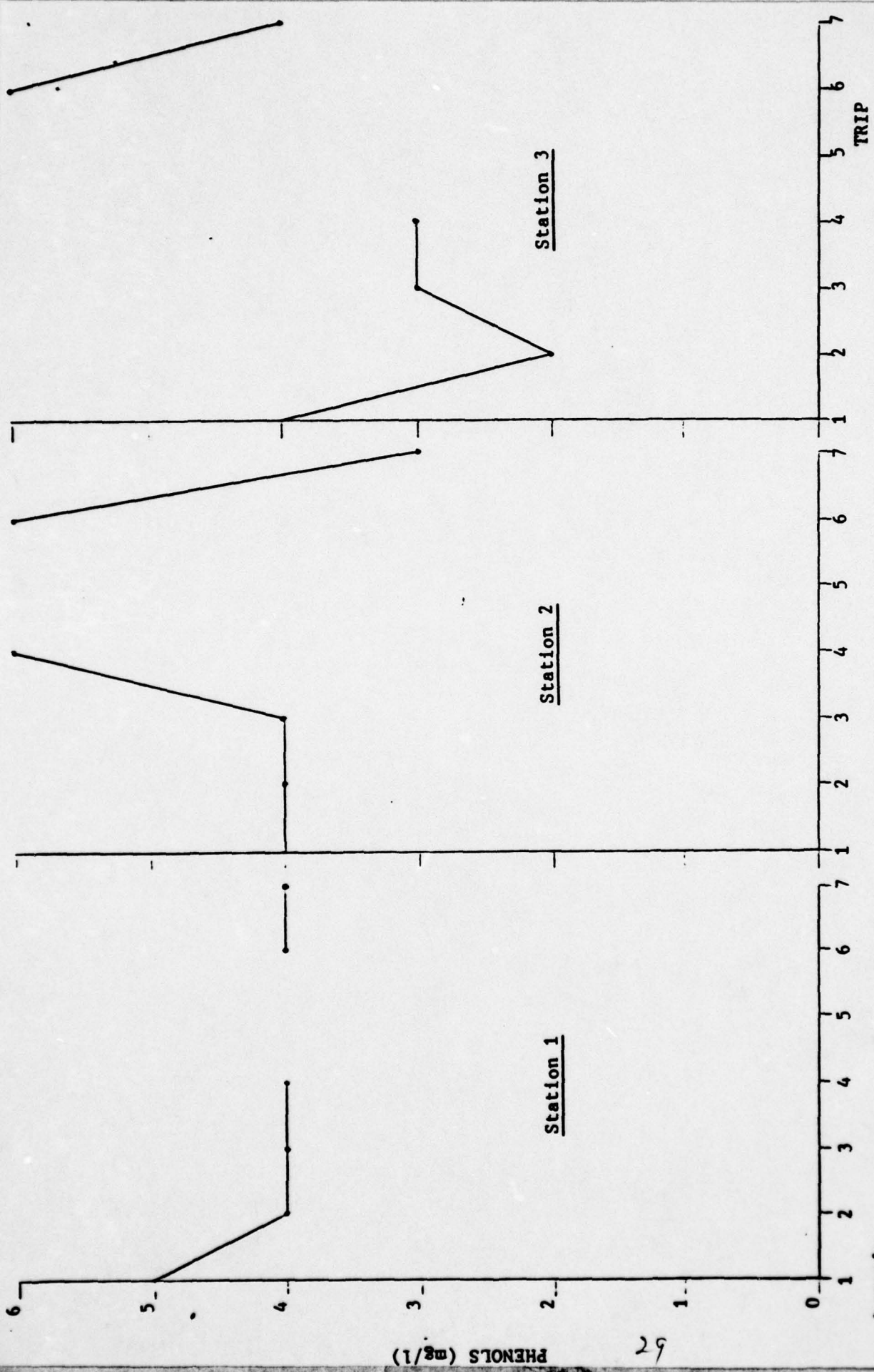


Figure 12
PHENOLS

Legend:
 — Top
 - - - Midpoint
 - - - Bottom

PHENOLS (mg/l)

29

TRIP

Station 3

Station 2

Station 1

remained constant at 4.0 mg/l through August 20. On September 2, the phenols level at this station exhibited a sharp increase, reaching 6.0 mg/l. This level remained constant until November 5, when a reading of 4.0 mg/l was recorded. By August 20, the phenols level of Station 3 had increased to 3.0 mg/l. This level remained constant until October 3, when a phenols level of 6.0 mg/l was recorded. On November 5, the phenols level of Station 3 had decreased to 4.0 mg/l, which was consistent with its pre-application level.

Herbicides (2,4-D and Diquat)

The concentrations of 2,4-D and Diquat underwent increases at Stations 1 and 2 immediately following the application of the respective herbicides. Neither of these agents were detected at Station 3. In each instance, pre-application herbicide levels were reestablished by the time of the following sample trip (Figure 13).

At the time of the July 24 preliminary sampling, the study area was found to be free of any traces of 2,4-D (Table 11). On August 7, which was three days after the initial application of 30 tons of granular 2,4-D, the 2,4-D concentration at Station 1 was found to have increased to 12.0 parts per billion (ppb), while the 2,4-D level at Station 2 had increased to 68.0 ppb. No 2,4-D was recorded from Station 3. By August 20, the 2,4-D level of the study area had returned to zero. No further positive 2,4-D readings were made throughout the duration of the study.

The Diquat concentration of the study area maintained a constant level of zero through the third sampling on August 20 (Table 12). On September 2, which

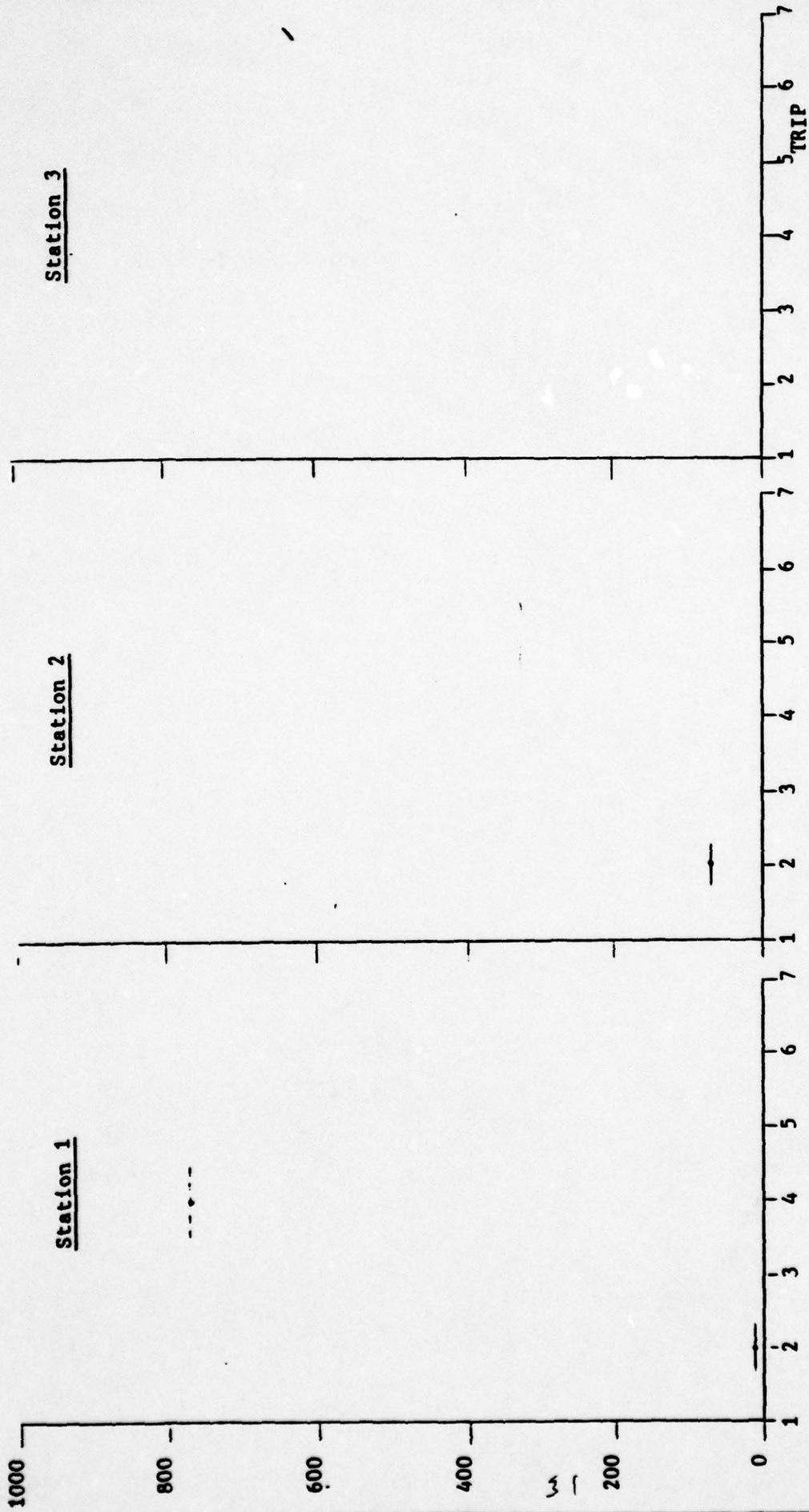


Figure 13
HERBICIDES

Legend:
 — 2,4-D
 - - - Diquat

was seven days after the initial application of Ortho-Diquat, the Diquat level of Station 1 increased to 770.0 ppb. No Diquat was detected at Stations 2 or 3. No further herbicide samples were collected during the remainder of the study.

Phytoplankton

The phytoplankton populations of the three sampling stations underwent a sharp decrease in density following the application of 2,4-D to the study area. Following the application of Ortho-Diquat to the area, the phytoplankton population underwent a severe increase in numbers. This increase was short-lived, with pre-application levels generally being reestablished by October 3 (Figure 14).

During the preliminary sampling trip of July 24, the phytoplankton densities of the three stations were found to range from 370 to 510 organisms/ml (Table 13). On August 7, which was three days after the application of 2,4-D, the phytoplankton density of the study area exhibited a sharp decrease, reaching levels of 110 to 280 organisms/ml. This trend toward a reduction in phytoplankton density continued through August 20 at Stations 1 and 3, while a slight increase was recorded at Station 2. On this date, the phytoplankton density ranged from 110 to 250 organisms/ml.

On September 2, which was seven days after the initial application of Diquat, the phytoplankton density of the study area underwent a sudden sharp increase. On this date, the phytoplankton populations of the three stations were found to range from 1400 to 1970 organisms/ml. This increase in phytoplankton

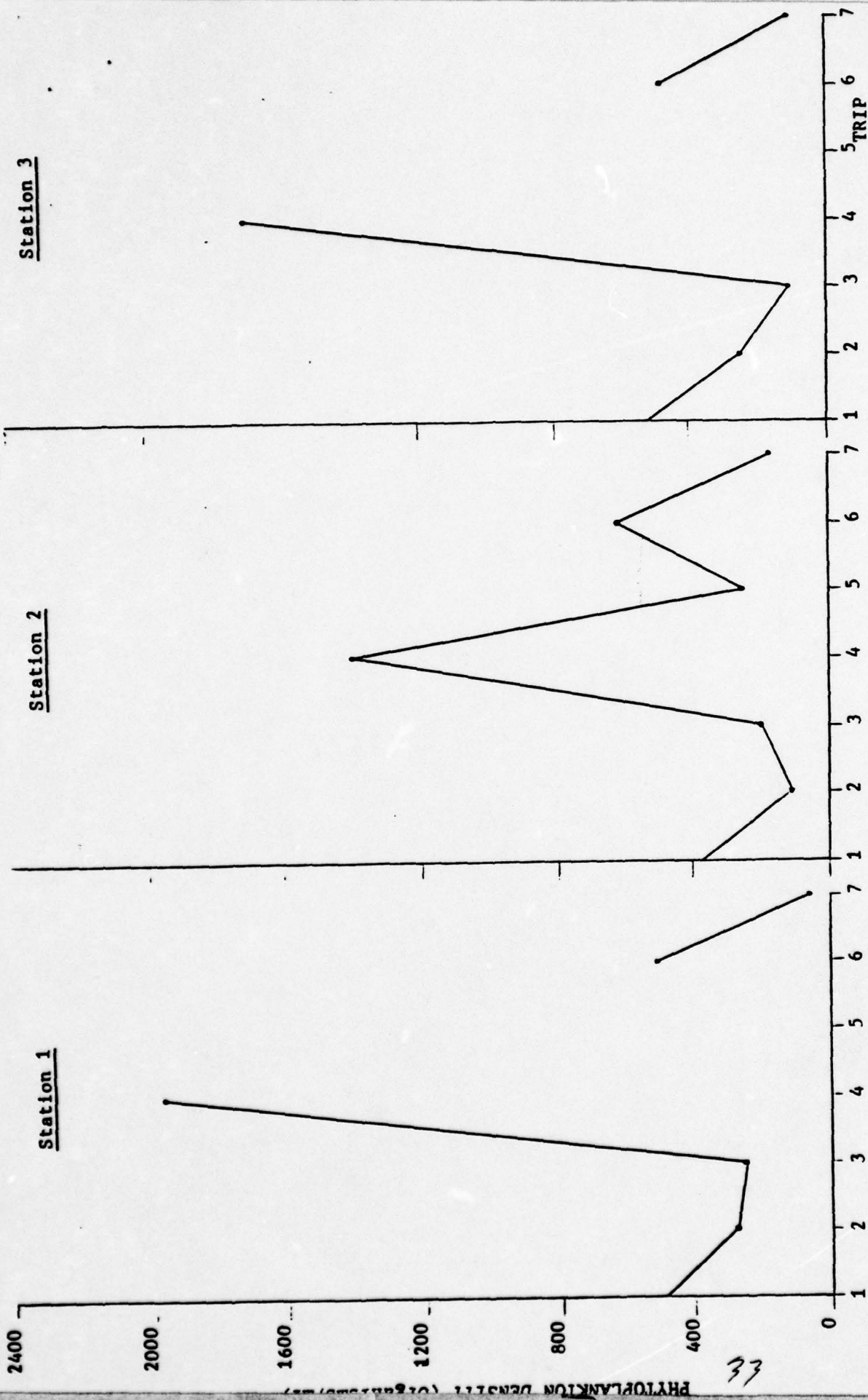


Figure 14
PHYTOPLANKTON DENSITY

density was extremely short-lived, for on September 9 the phytoplankton level at Station 2 was found to be only 340 organisms/ml. This trend toward decreased phytoplankton density continued throughout the duration of the study. On November 5, the last sampling date, the phytoplankton density of the study area ranged from 60 to 170 organisms/ml.

The composition of the phytoplankton population also underwent several changes during the study (Figure 15). On July 24, blue-green algae comprised approximately 20% of the phytoplankton population at each of the three stations (Table 14). On August 7, which was three days after the application of 2,4-D, blue-greens were totally absent from Stations 1 and 2, and comprised only 11% of the phytoplankton population of Station 3. Blue-green algae were not again recorded from the study area until September 2, when they comprised approximately 5% of the population at Stations 1 and 2. Blue-greens were not again detected at Stations 1 and 3, throughout the duration of the study; and not until November 5 at Station 2, when they made up approximately 17% of the phytoplankton population.

During the first three sampling periods, diatoms were the dominant taxa of phytoplankton recorded from the study area, generally comprising approximately 80% of the populations. On September 2, which was seven days after the initial application of Ortho-Diquat, flagellates were found to be the dominant phytoplankton group, comprising approximately 65 to 80% of the phytoplankton populations. During the Lake Study sampling on September 9, flagellates remained the dominant taxa at Station 2, making up 67% of the total phytoplankton population. By October 3, diatoms had re-established themselves as the

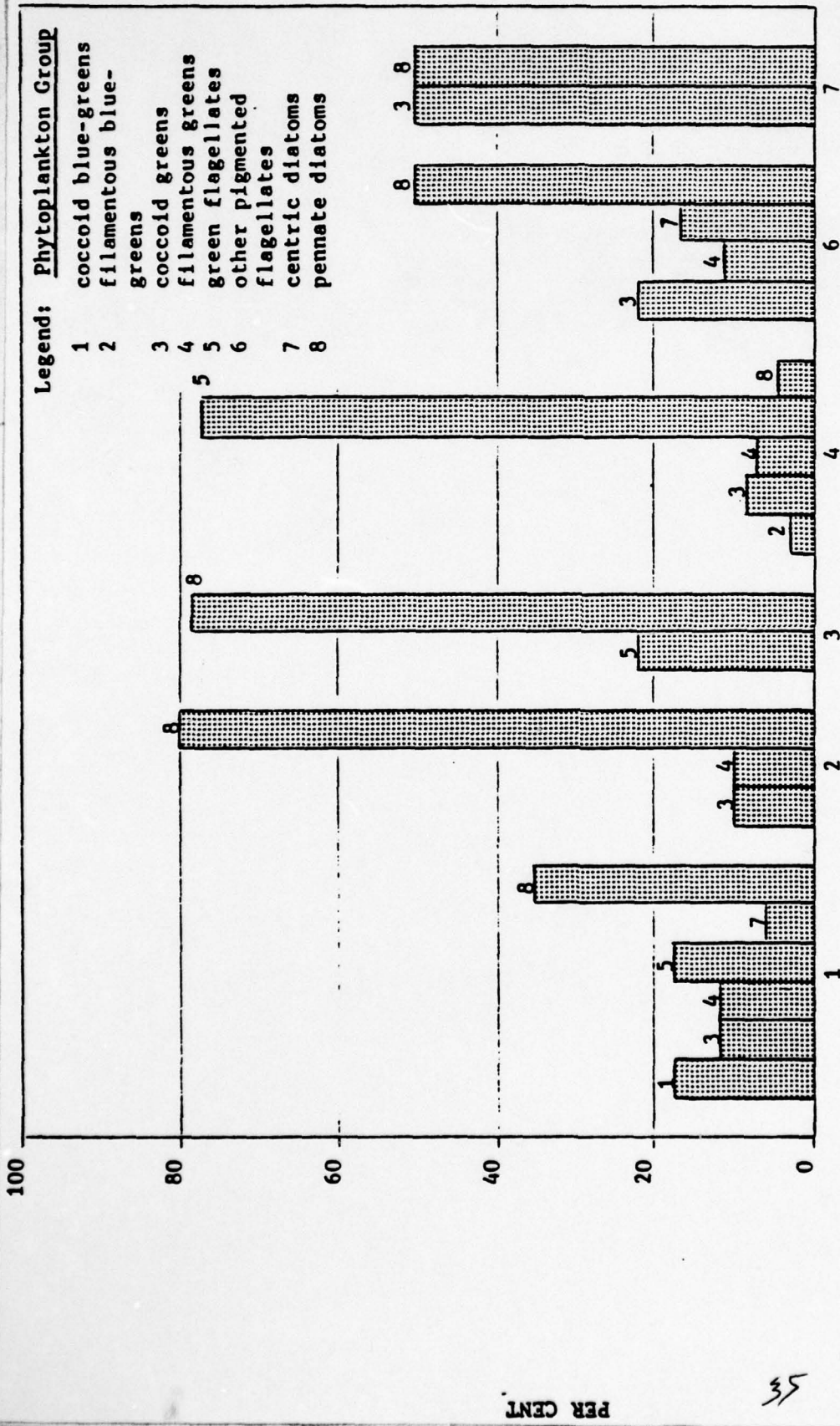


Figure 15
Station 1
PHYTOPLANKTON COMPOSITION

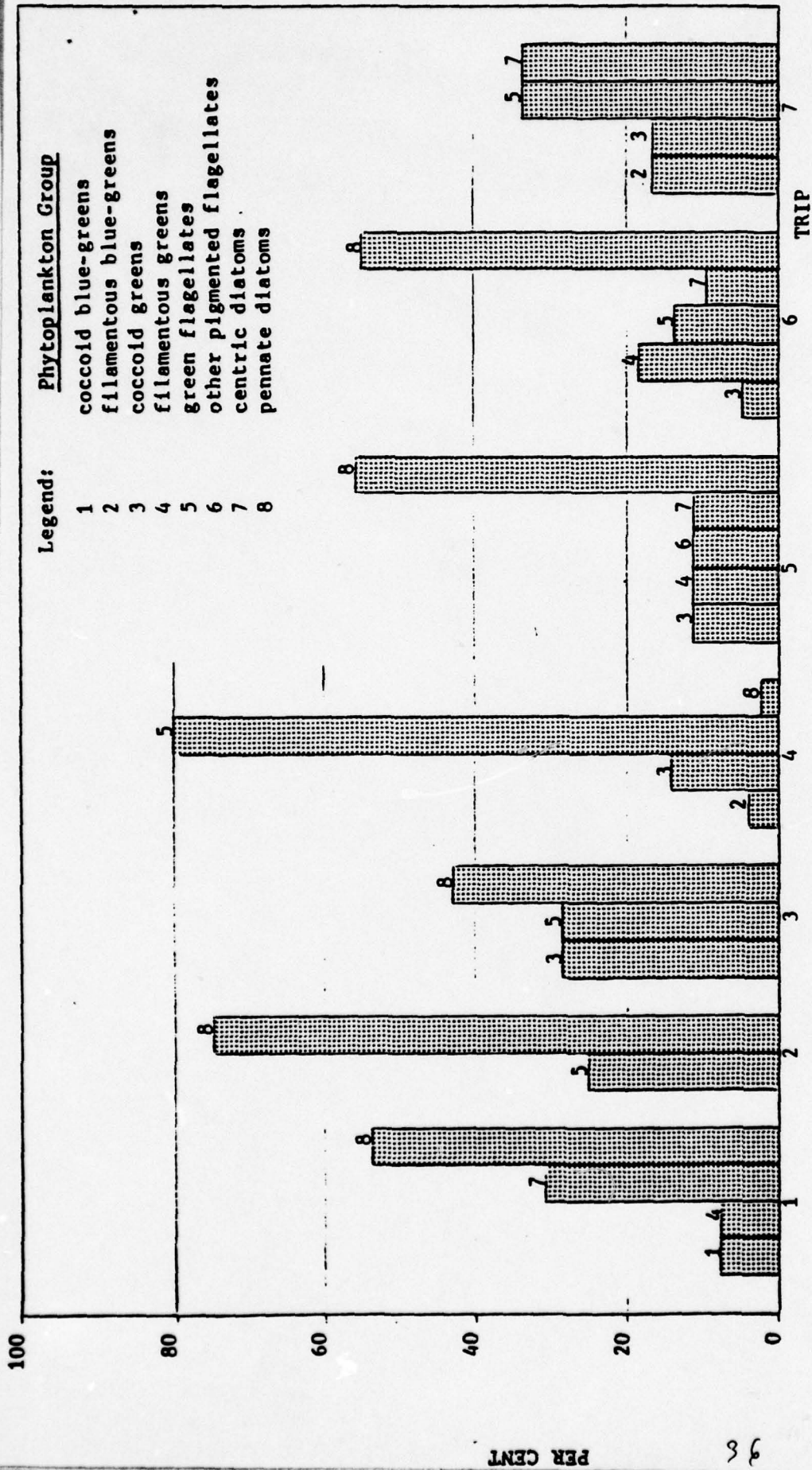


Figure 15 (cont.)

Station 2

PHYTOPLANKTON COMPOSITION

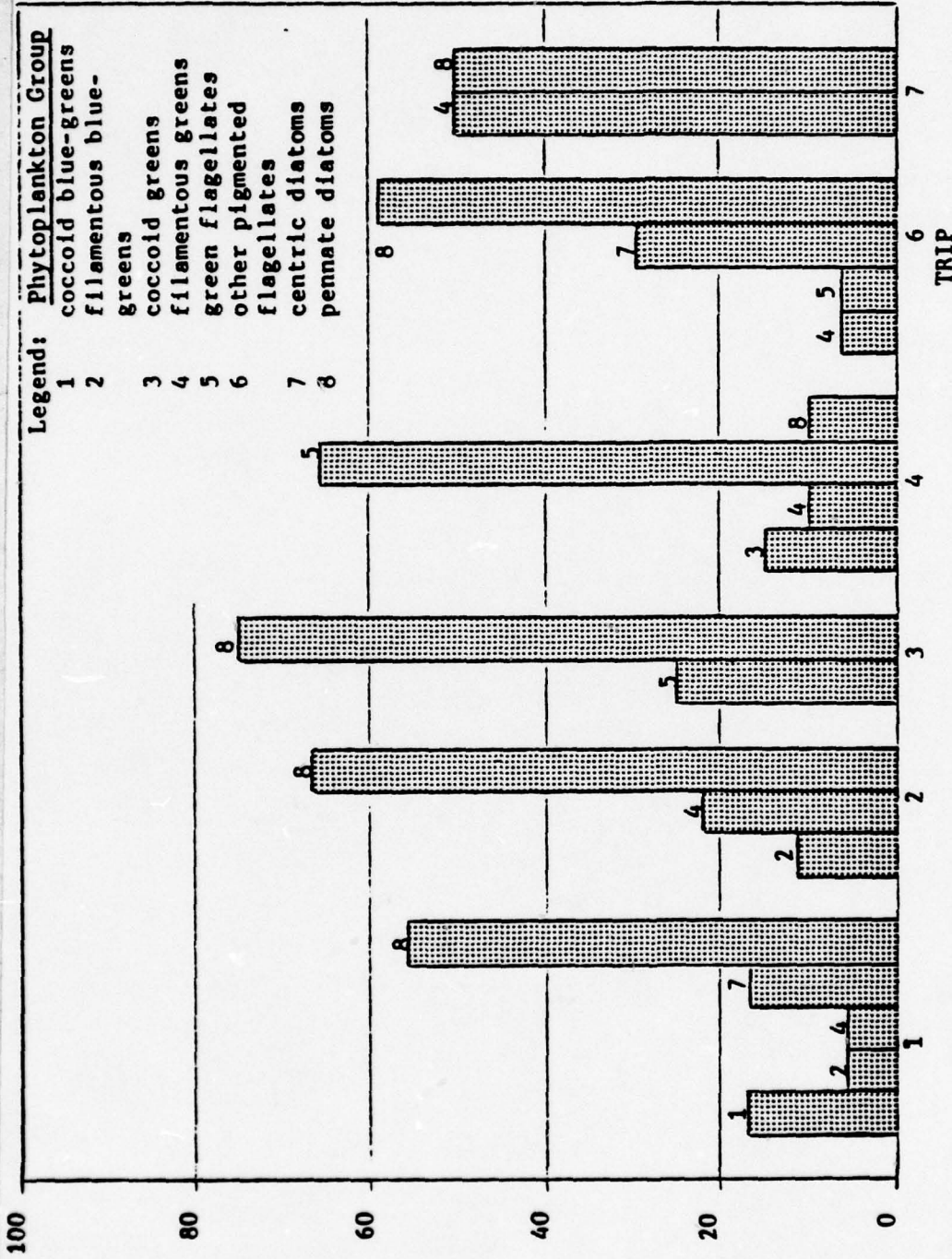


Figure 15 (cont.)

Station 3

PHYTOPLANKTON COMPOSITION

dominant phytoplankton group, comprising 65 to 90% of the population.

On November 5, the phytoplankton population of the study area was generally found to exhibit a greater diversity than had been recorded since July 24. At Station 1, diatoms and green algae each comprised 50% of the population; at Station 2, diatoms and flagellates were the dominant groups, with large numbers of blue-green and green algae also being recorded; and at Station 3, diatoms and green algae each made up 50% of the phytoplankton population.

Chlorophyl a

Each of the three sampling stations exhibited distinct local variations in chlorophyl a levels; however, Stations 2 and 3 exhibited similar trends. Station 1 generally exhibited the highest chlorophyl a level throughout the study. The chlorophyl a level of Station 1 underwent a slight decrease following the application of 2,4-D, while the levels at Stations 2 and 3 exhibited sharp increases. Following the application of Diquat, the chlorophyl a level of Station 1 underwent a small increase while the levels of Stations 2 and 3 demonstrated sudden decrease. Near minimum chlorophyl a levels for all stations were recorded on October 3 which was the last time chlorophyl levels were measured (Figure 16).

Chlorophyl a was not measured on July 24 or November 5. On August 7, the chlorophyl a level of Station 1 was 56 ug/l, while the levels of Stations 2 and 3 were 2 ug/l and 6.7 ug/l, respectively (Table 15). On August 20, the chlorophyl a level of Station 1 had decreased to 40 ug/l, while the levels of Stations

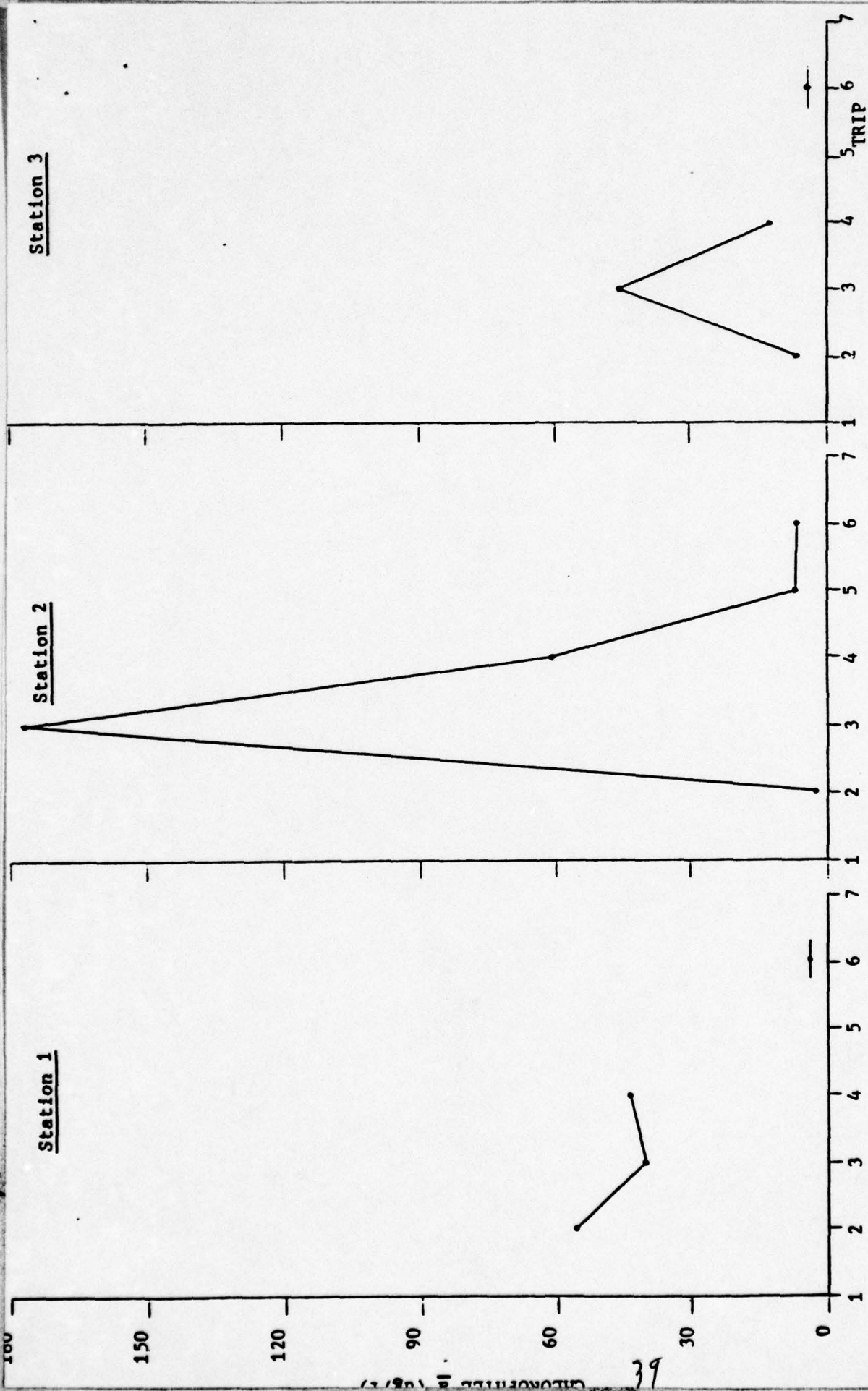


Figure 16
CHLOROPHYLL a

2 and 3 exhibited sharp increases to reach 176 ug/l and 45 ug/l. On September 2, the chlorophyl a level of Station 1 exhibited a slight increase to reach a level of 43 ug/l, while the level of the remaining two stations exhibited a sharp decrease to reach levels of 60 ug/l at Station 2 and 12 ug/l at Station 3. On October 3, the chlorophyl a levels of the three stations were quite similar, and were generally the minimum values recorded. On this date, the chlorophyl a levels of the study area ranged from 3.4 to 6.1 ug/l.

DISCUSSION

Dissolved Oxygen

The study data indicates that the dissolved oxygen (D.O.) levels of the study area were adversely affected by the application of 2,4-D and Ortho-Diquat. Prior to the application of these herbicides, the dissolved oxygen levels of the three sampling stations were consistent with the D.O. levels recorded from cypress-tupelo regimes throughout the state, ranging from 3.0 to 6.0 mg/l. Following the application of 30 tons of granular 2,4-D on August 4-6, the D.O. of the study area exhibited a sharp decrease. This trend toward decreased dissolved oxygen levels continued through September 2. On October 3, the D.O. of the study area exhibited a sharp increase. The D.O. level continued to rise through November 5, when pre-application levels were re-established (Figure 4).

The decreased dissolved oxygen levels were primarily caused by the decomposition of the dead plant material resulting from the application of herbicides to such a large expanse of aquatic vegetation.

The problem of decreased D.O. levels, caused by the oxidation of dead plant material, was compounded by a decrease in the water level of Lake Marion immediately following the application of 2,4-D (Figure 17). Due to this period of low water, a sufficient flow of water was not present to flush the dead plant material from the area. As a result, much of the plant material remained in the study area, resulting in the extremely low D.O. readings. Prior to the sampling trip of October 3, the water level of the lake exhibited a sharp in-

crease, rising approximately 0.75 feet since the preceding sampling. This influx of fresh water significantly raised the D.O. level of the area.

The South Carolina Department of Health and Environmental Control classifies Lake Marion as Class A waters. The Department's water classification standards system states that "the dissolved oxygen level of Class A waters may not be less than 5 mg/l, except that swamp waters may have an average of 4 mg/l". Even if the Rimini Trestle-Pack's Landing area of Lake Marion should be classified as a swamp area, the application of 2,4-D and Ortho-Diquat caused a contravention of State dissolved oxygen standards from August 7 to October 3, 1975.

pH

The pH levels of the study area underwent sharp increases immediately following the application of Ortho-Diquat. Prior to the application of this material, the pH of the study area averaged 6.5 standard units. On September 2, the pH of the area rose to a maximum of 8.3 standard units (Figure 5).

The sharp rise in pH may be attributed to the breakdown of the large dose of Ortho-Diquat. This problem was compounded by the low flow conditions which prevailed at the time. The influx of fresh water into Lake Marion during the last two weeks of September acted to return the pH of the study area to the pre-application levels.

State water quality standards for Class A waters call for pH to range from 6.0 to 8.0 standard units, except that swamp waters may range from 5.0 to 8.0 standard units. As a result of the application of Diquat to the study area,

State water quality standards for pH were contravened at one station and approached at another.

Specific Conductance

The specific conductance of Stations 1 and 2 underwent sharp increases following the application of 2,4-D to the study area. Peak conductivity levels at these stations were recorded two weeks following the application of this herbicide. The conductivity levels of Station 3 remained relatively constant throughout the study (Figure 6). Due to equipment malfunction, the effect of Diquat on the conductivity of the area was undetermined.

The rise in conductivity at Stations 1 and 2 following the application of 2,4-D can primarily be attributed to the release of inorganic materials through the decomposition of the dead plant material. This problem was compounded by the low dilution rate which persisted in the area during the dry period from August 1 to September 15. The decrease in maximum specific conductance levels which were observed from August 20 through October 3 may have been the result of increased dilution due to rainfall and surface runoff (Figure 17). Similarly, the lower conductivity levels recorded at Station 3 may be attributed to dilution, due to the proximity of this station to the Santee River.

Biochemical Oxygen Demand (5-Day)

The study data indicates that the BOD₅ level of the study area was adversely affected by the application of 2,4-D and Ortho-Diquat. Prior to the application of these herbicides, the BOD₅ levels of the study area ranged from 0.5

to 1.0 mg/l. Following the application of 2,4-D, the BOD₅ levels exhibited a slight increase. Following the application of Ortho-Diquat, the BOD₅ levels of the area underwent a sharp increase. This increase was short-lived, however, as near pre-application levels were re-established by September 9 (Figure 7).

Several factors are felt to have contributed to the rise in BOD₅ levels. The decomposition of the large amounts of dead plant material probably exerted the most significant demand on the oxygen supply of the study area. Contributing to this stress was the sharp rise in phytoplankton populations which occurred immediately following the application of Ortho-Diquat (Figure 14). The chemical breakdown of the 2,4-D and Diquat also exerted a demand on the oxygen of the study area.

The decrease in the water level of Lake Marion immediately following the application of 2,4-D acted to compound the significance of the preceding factors. Due to this period of low water, a sufficient flow was not available to flush the dead plant material from the area. Conversely, the rapid decrease in BOD₅ levels which occurred during the first week of September was due to the increase in the lake level during this same period (Figure 17).

Total Alkalinity (CaCO₃)

Total alkalinity values of the study area were affected to a small degree by the application of 2,4-D. Prior to the application of 2,4-D, the total alkalinity of the study area ranged from 8.0 to 12.0 mg/l. Following the application of 2,4-D, a trend toward increased total alkalinity levels was observed,

until maximum levels, ranging from 18.0 to 30.0 mg/l, were recorded on August 20 (Figure 8).

The rise in total alkalinity is felt to be directly related to the decomposition of the dead plant material which resulted from the application of 2, 4-D to such a large expanse of aquatic vegetation. As with many of the other parameters sampled, this problem was compounded by the period of low water which occurred in Lake Marion immediately following the application of 2,4-D.

Color

The color levels of the study area were severely altered by the application of herbicides. Prior to the application of 2,4-D, the color level of the Pack's Landing area ranged from 45 to 70 color units. Following the application of 2, 4-D, the color level exhibited an increase, until maximum levels ranging from 120 to 240 color units were reached on August 20 (Figure 9).

Color in water is primarily caused by complex organic compounds originating from the decomposition of naturally-occurring organic matter. In the case of the study area, the sharp rise in color was due to the decomposition of the vast amount of plant material killed by the application of 2,4-D and Diquat. As was observed with many of the other parameters studied, the low water which occurred in Lake Marion immediately following the application of 2,4-D tended to concentrate the dead plant material in the study area, acting to compound the color problem. Original color levels were re-established by October 3, following a sharp increase in the lake level.

Turbidity

The application of 2,4-D had a severe impact on the turbidity levels of the study area. Prior to the application of 2,4-D, the turbidity levels of the study area ranged from 3.5 to 4.5 units. Following the initial herbicide application, the turbidity levels increased, reaching values ranging from 30 to 150 units (Figure 10).

As was the case with many of the other parameters studied, it is felt that the increase in turbidity was caused by the decaying plant material. This problem was compounded by the low water level which occurred in Lake Marion following the application of 2,4-D, as sufficient flow was not present to diffuse the dead plant material throughout the lake system. As the water level in the lake increased, the turbidity level of the study area decreased to pre-application levels.

Total Organic Carbon (TOC)

The total organic carbon levels of the study area exhibited a sharp increase following the application of herbicides. Peak TOC levels for Stations 2 and 3 were reached two weeks following the application of 2,4-D; while peak levels for Station 1 were reached immediately following the application of Ortho-Diquat (Figure 11).

The rise in TOC levels following the application of herbicides to the study area can primarily be attributed to the decomposition of the dead plant material. This problem was compounded by the low dilution rate which persisted during the dry period from August 1 to September 15. The TOC levels of the

study area exhibited a significant decrease on October 3, following a sharp rise in the lake level.

Phenols

Phenolic compound levels of two of the sampling stations rose sharply following the application of Ortho-Diquat to the study area. Prior to the application of herbicides, the phenol level of the sampling area ranged from 4.0 to 5.0 mg/l. Peak levels were recorded on October 3, when Stations 2 and 3 exhibited a phenolic compound level of 6.0 mg/l (Figure 12).

The rise in the phenolic compound levels of the study area may primarily be attributed to the chemical oxidation and microbial degradation of the applied herbicides. Increased phenol levels existing under the conditions which prevailed in the study area during this period pose unusual environmental hazards, as lowered dissolved oxygen concentrations have been shown to increase the toxicity of phenol.

As with many of the other parameters studied, the low flow conditions which existed in Lake Marion following the application of 2,4-D is felt to have acted to concentrate the rise in phenolic compounds. The phenol level of the study area decreased following the rise in the lake level.

Herbicides (2,4-D and Diquat)

Prior to August 7, the waters of the study area were found to be free of any traces of 2,4-D or Diquat. Following the application of each of the herbicides,

positive results were recorded for the respective agents during the sampling effort immediately following their application. The maximum 2,4-D level recorded from the area was 68.0 ug/l at Station 2 on August 7; while the maximum Diquat reading was 770 ug/l at Station 1 on September 2 (Figure 13). None of the 2,4-D persisted in the water column of the study area for longer than two weeks. Due to limited laboratory facilities, it was impossible to determine the persistency of the Ortho-Diquat.

The rapid disappearance of the two herbicides from the study area may be accounted for by several factors. First, much of the herbicides may have been taken-up by the target plants and either degraded, volatilized, or transported away with the dead plant material. Second, some of the herbicide may have interacted with suspended matter and sediment. Once associated with suspended matter, the herbicides would have then eventually entered the sediment. Once in the sediment, the herbicide would have been re-released into the water, taken up by organisms, altered or degraded by microorganisms, or simply buried. Third, the herbicide which remained in the water column may have been sorbed by the sediments, degraded by microorganisms, taken up by other organisms, or diluted by the waters of the lake.

Phytoplankton

The application of herbicides had a severe affect on the phytoplankton population of the study area. Following the application of 2,4-D, the phytoplankton density of each of the three sampling stations exhibited a sharp decrease. Immediately following the application of Ortho-Diquat, a pronounced

increase in phytoplankton density was recorded at each of the stations. A period of approximately one month was required for reestablishment of original phytoplankton densities (Figure 14).

The application of herbicides is felt to have had both direct and indirect effects on the phytoplankton density of the study area. The initial phytoplankton die-off was primarily caused by the direct toxicity of the granular 2,4-D. The phytoplankton populations were then held at their reduced numbers by the decreased level of light penetration caused by the substantially increased color and turbidity of the waters of the study area. Following an influx of fresh water into the study area, the color and turbidity levels exhibited a sharp decrease. This reduction in color and turbidity allowed greater light penetration, resulting in the marked increase in phytoplankton density recorded on September 2. Natural processes then interacted to return the phytoplankton populations to their pre-application densities.

Chlorophyl a

Chlorophyl a levels of the study area were sharply altered by the application of herbicides. Although each of the three sampling stations exhibited distinct local variations, the general trend was that chlorophyl a levels increased sharply following the application of 2,4-D. These increased levels were short-lived, as a sudden decrease was demonstrated immediately following the application of Ortho-Diquat (Figure 16).

The increase in chlorophyl a levels following the application of 2,4-D can be attributed to the cellular destruction of the large expanse of affected plant

material, and the subsequent release of chlorophyl containing material. As was the case with many of the other parameters, the low flow conditions which prevailed following the application of 2,4-D tended to concentrate this material, leading to higher chlorophyl a readings. Following the application of Ortho-Diquat, the lake level exhibited a sharp increase. This influx of fresh water acted to flush the dead plant material from the area, resulting in decreased chlorophyl a levels.

CONCLUSIONS

The application of 30 tons of granular 2,4-D and 1,500 gallons of Ortho-Diquat to the Rimini Trestle-Pack's Landing area of Lake Marion by the South Carolina Public Service Authority caused severe degradation of water quality in the target area. Those parameters which exhibited marked damage include dissolved oxygen, pH, specific conductance, biochemical oxygen demand, total alkalinity, color, turbidity, total organic carbon, phenols, herbicide levels, phytoplankton populations, and chlorophyl a.

The degradation of water quality in the target area was primarily caused by the decomposition of the large expanse of dead plant material. This problem was compounded by the low flow conditions which prevailed in Lake Marion from August 1 to September 15, 197⁵~~6~~. Due to this period of low water, a sufficient flow was not present to flush the decaying plant matter from the study area. This tended to concentrate the decomposing plant material in a small area, thereby leading to the degradation of water quality.

The detrimental effects of the herbicide applications generally persisted until October 3, which was 61 days following the initial application of 2,4-D. The water quality of the study area demonstrated near complete recovery following a sharp rise in the lake's water level. The influx of fresh water acted to flush the decaying plant material from the study area and to disperse it throughout the lake system.

RECOMMENDATIONS

- I. Chemical control of large expanses of aquatic vegetation should be utilized only as a last resort. All alternative methods of control, such as biological, mechanical, and physical, should be thoroughly investigated.
- II. If chemical control must be utilized, the following points should be considered:
 - a. treat early in the growing season while plants are young and tender, and before hot weather and low flow conditions prevail;
 - b. treat only small areas at a time, and allow sufficient time for water quality to recover before additional areas are treated;
 - c. carry out a continuing water quality monitoring program, both in conjunction with and following the control activities, so that any detrimental effects on water quality and/or aquatic wildlife may be determined early and appropriate corrective measures taken;
 - d. closely adhere to all herbicide label directions. According to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as Amended, any use of a pesticide in a manner inconsistent with its labeling shall be considered as a violation of the law, effective October 21, 1977.

TABLE I

WATER TEMPERATURE (°C)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	26.0	26.0	26.0	27.0	27.0	26.5	26.0	26.0	26.0
8-7	27.0	27.0	27.0	28.0	28.0	28.0	27.0	27.0	27.0
8-20	29.0	28.0	28.0	32.0	29.0	29.0	29.0	29.0	29.0
9-2	28.0	27.0	27.0	27.0	26.0	26.0	28.0	27.0	27.0
9-10	-	-	-	30.0	30.0	30.0	-	-	-
10-3	21.0	21.0	21.0	22.00	22.0	21.0	22.0	22.0	21.0
11-5	17.0	17.0	17.0	17.5	17.0	17.0	18.5	18.0	18.0

TABLE II

DISSOLVED OXYGEN (mg/l)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	4.8	4.6	4.3	3.0	3.0	3.0	6.0	6.0	6.0
8-7	3.0	1.4	0.8	5.2	2.4	2.4	1.8	1.4	1.4
8-24	1.2	0.2	0.5	5.0	0.2	0.5	2.0	1.2	1.3
9-2	1.0	0.2	0.3	1.0	0.2	0.3	2.7	0.8	0.6
9-10	-	-	-	0.4	0.2	0.2	-	-	-
10-3	3.0	3.4	3.2	2.8	2.9	3.2	3.8	3.8	3.1
11-5	5.4	5.4	5.6	3.8	4.0	4.0	5.5	3.8	3.4

TABLE III

pH

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	6.5	6.5	6.5	6.5	6.5	6.4	6.5	6.5	6.5
8-7	6.2	6.4	6.4	6.3	6.7	6.5	6.5	6.6	6.6
8-20	6.2	6.3	6.3	6.3	6.2	6.2	6.5	6.4	6.4
9-2	6.1	-	6.0	8.0	-	6.9	8.3	-	7.6
9-10	-	-	-	6.3	6.4	6.5	-	-	-
10-3	6.4	6.7	6.7	6.8	6.8	6.8	6.8	6.7	6.7
11-5	6.5	-	-	6.5	-	-	6.5	-	-

TABLE IV

SPECIFIC CONDUCTANCE (umhos/cm)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	80	80	80	81	83	83	85	85	85
8-7	90	90	92	90	90	90	95	95	100
8-20	115	125	130	125	132	142	92	92	95
9-2	-	-	-	-	-	-	-	-	-
9-10	-	-	-	120	120	120	-	-	-
10-3	97	99	99	100	100	100	-	-	-
11-5	110	115	125	110	110	110	110	110	105

TABLE V

BIOCHEMICAL OXYGEN DEMAND (mg/l)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	0.7	-	-	1.0	-	-	0.5	-	-
8-7	1.4	-	-	1.8	-	-	0.3	-	-
8-20	2.5	-	-	2.1	-	-	1.4	-	-
9-2	4.0	-	-	5.6	-	-	4.6	-	-
9-10	-	-	-	0.5	0.8	1.4	-	-	-
10-3	1.6	-	-	1.1	-	-	0.9	-	-
11-5	1.7	-	-	1.2	-	-	1.0	-	-

TABLE VI

TOTAL ALKALINITY (mg/l)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	8.0	-	-	9.0	-	-	12.0	-	-
8-7	16.0	-	-	16.0	-	-	14.0	-	-
8-20	20.0	-	-	30.0	-	-	18.0	-	-
9-2	22.0	-	-	14.0	-	-	14.0	-	-
9-10	-	-	-	20.0	20.0	20.0	-	-	-
10-3	12.0	-	-	14.0	-	-	14.0	-	-
11-5	14.0	-	-	14.0	-	-	16.0	-	-

TABLE VII

COLOR

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	65.0	-	-	45.0	-	-	70.0	-	-
8- 7	70.0	-	-	60.0	-	-	50.0	-	-
8-20	240.0	-	-	240.0	-	-	120.0	-	-
9- 2	100.0	-	-	90.0	-	-	80.0	-	-
9-10	-	-	-	100.0	80.0	100.0	-	-	-
10- 3	60.0	-	-	50.0	-	-	40.0	-	-
11- 5	40.0	-	-	40.0	-	-	40.0	-	-

TABLE VIII

TURBIDITY

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	3.5	-	-	3.5	-	-	4.5	-	-
8- 7	1.8	-	-	2.3	-	-	2.4	-	-
8-20	105.0	-	-	105.0	-	-	30.0	-	-
9- 2	5.5	-	-	5.4	-	-	2.5	-	-
9-10	-	-	-	3.2	3.2	3.4	-	-	-
10- 3	-	-	-	-	-	-	-	-	-
11- 5	8.6	-	-	8.5	-	-	11.0	-	-

TABLE IX

TOTAL ORGANIC CARBON (mg/l)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	-	-	-	-	-	-	-	-	-
8- 7	13.9	-	-	12.5	-	-	11.4	-	-
8-20	14.0	-	-	16.4	-	-	19.0	-	-
9- 2	17.0	-	-	13.5	-	-	10.4	-	-
9-10	-	-	-	-	-	-	-	-	-
10- 3	6.6	-	-	4.6	-	-	3.8	-	-
11- 5	3.9	-	-	3.5	-	-	3.3	-	-

TABLE X

PHENOLS (mg/l)

Date (1975)	Station								
	1			2			3		
	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
7-24	5.0	-	-	4.0	-	-	4.0	-	-
8- 7	4.0	-	-	4.0	-	-	2.0	-	-
8-20	4.0	-	-	4.0	-	-	3.0	-	-
9- 2	4.0	-	-	6.0	-	-	3.0	-	-
9-10	-	-	-	-	-	-	-	-	-
10- 3	4.0	-	-	6.0	-	-	6.0	-	-
11- 5	4.0	-	-	3.0	-	-	4.0	-	-

TABLE XI

HERBICIDES (ug/l)

Date (1975)	Station					
	1		2		3	
	2,4-D	Diquat	2,4-D	Diquat	2,4-D	Diquat
7-24	0.0	0.0	0.0	0.0	0.0	0.0
8-7	12.0	-	68.0	-	0.0	-
8-20	0.0	0.0	0.0	0.0	0.0	0.0
9-2	0.0	770.0	0.0	0.0	0.0	0.0
9-10	-	-	-	-	-	-
10-3	-	-	-	-	-	-
11-5	-	-	-	-	-	-

TABLE XII

PHYTOPLANKTON DENSITY (Organisms/ml)

Date (1975)	Station		
	1	2	3
7-24	480	370	510
8-7	280	110	250
8-20	250	200	110
9-2	1970	1400	1700
9-10	-	250	-
10-3	510	620	480
11-5	60	170	110

TABLE XIII

PHYTOPLANKTON COMPOSITION (% of total population)

Phytoplankton Groups	Station I						
	7-24	8-7	8-20	9-2	9-10	10-3	11-5
coccoid blue-greens	17.6				-		
filamentous blue-greens				2.9	-		
coccoid greens	11.8	10.0		8.6	-	22.2	50.0
filamentous greens	11.8	10.0		7.1	-	11.1	
green flagellates	17.6		22.0	77.1	-		
other pigmented flagellates					-		
centric diatoms	5.9				-	16.7	
pennate diatoms	35.3	80.0	78.0	4.3	-	50.0	50.0

TABLE XIII (cont.)

Phytoplankton Groups	Station 2						
	7-24	8-7	8-20	9-2	9-10	10-3	11-5
coccoid blue-greens	7.7				-		
filamentous blue-greens				4.0	-		16.7
coccoid greens			28.6	14.0	11.1	4.5	16.7
filamentous greens	7.7				11.1	18.2	
green flagellates		25.0	28.5	80.0	-	13.6	33.3
other pigmented flagellates					11.1		
centric diatoms	30.8				11.1	9.1	33.3
pennate diatoms	53.8	75.0	42.9	2.0	55.6	54.6	

TABLE XIII (cont.)

Phytoplankton Groups	Station 3						
	7-24	8-7	8-20	9-2	9-10	10-3	11-5
coccoid blue-greens	16.7				-		
filamentous blue-greens	5.5	11.1			-		
coccoid greens				14.8	-		
filamentous greens	5.5	22.2		9.8	-	5.9	50.0
green flagellates			25.0	65.6	-	5.9	
other pigmented flagellates					-		
centric diatoms	16.7				-	29.4	
pennate diatoms	55.6	66.7	75.0	9.8	-	58.8	50.0

TABLE IV

CHLOROPHYLL a (ug/l)

Date (1975)	Station		
	1	2	3
7-24			
8-7	56.187	2.177	6.712
8-20	40.785	176.761	45.646
9-2	43.707	60.688	12.351
9-10		7.04	
10-3	3.471	6.184	3.831
11-5			